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THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE[1]*—I.*

Before entering on the subject of my address, I may be allowed to refer to the loss which the British Association has sustained in the death of Lord Kelvin. He joined the association in 1847, and has been for more than fifty years a familiar figure at our meetings. This is not the occasion to speak of his work in the world or of what he was to his friends, but rather of his influence on those who were personally unknown to him. It seems to me characteristic of him that something of his vigor and of his personal charm was felt far beyond the circles of his intimate associates, and many men and women who never exchanged a word with Lord Kelvin, and are in outer darkness as to his researches, will miss his genial presence and feel themselves the poorer to-day. By the death of Sir John Evans the association is deprived of another faithful friend. He presided at Toronto in 1897, and since he joined the association in 1861 had been a regular attendant at our meetings. The absence of his cheerful personality and the loss of his wise counsels will be widely felt.

May I be permitted one other digression before I come to my subject? There has not been a botanical president of the British Association since the Norwich meeting forty years ago, when Sir Joseph Hooker was in the chair, and in "eloquent and felicitous words" (to quote my fath-

[1] Dublin, 1908.

er's letter) spoke in defense of the doctrine of evolution. I am sure that every member of this association will be glad to be reminded that Sir Joseph Hooker is, happily, still working at the subject that his lifelong labors have so greatly advanced, and of which he has long been recognized as the honored chief and leader.

You will perhaps expect me to give a retrospect of the progress of evolution during the fifty years that have elapsed since July 1, 1858, when the doctrine of the origin of species by means of natural selection was made known to the world in the words of Mr. Darwin and Mr. Wallace. This would be a gigantic task, for which I am quite unfitted. It seems to me, moreover, that the first duty of your president is to speak on matters to which his own researches have contributed. My work—such as it is—deals with the movements of plants, and it is with this subject that I shall begin. I want to give you a general idea of how the changes going on in the environment act as stimuli and compel plants to execute certain movements. Then I shall show that what is true of those temporary changes of shape we describe as movements is also true of the permanent alterations known as morphological.

I shall insist that, if the study of movement includes the problem of stimulus and reaction, morphological change must be investigated from the same point of view. In fact, that these two departments of inquiry must be classed together, and this, as we shall see, has some important results —namely, that the dim beginnings of habit or unconscious memory that we find in the movements of plants and animals must find a place in morphology; and inasmuch as a striking instance of correlated morphological changes is to be found in the development of the adult from the ovum, I shall take this ontogenetic series and attempt to show you that here also something equivalent to memory or habit reigns.

Many attempts have been made to connect in this way the phenomena of memory and inheritance, and I shall ask you to listen to one more such attempt, even though I am forced to appear as a champion of what some of you consider a lost cause—the doctrine of the inheritance of acquired characters.

MOVEMENT

In his book on "The Power of Movement in Plants" (1880)[2] my father wrote that "it is impossible not to be struck with the resemblance between the foregoing movements of plants and many of the actions performed unconsciously by the lower animals." In the previous year Sachs[3] had in like manner called attention to the essential resemblance between the irritability of plants and animals. I give these statements first because of their simplicity and directness; but it must not be forgotten that before this Pfeffer[4] had begun to lay down the principles of what is now known as *Reizphysiologie,* or the physiology of stimulus, for which he and his pupils have done so much.

The words of Darwin which I have quoted afford an example of the way in which science returns to the obvious. Here we find revived, in a rational form, the point of view of the child or of the writer of fairy stories. We do not go so far as the child; we know that flowers do not talk or walk; but the fact that plants must be classed with animals as regards their manner of reaction to stimuli has now become almost a commonplace of physiology. And inasmuch as we ourselves are animals, this conception gives us

[2] P. 571.
[3] *Arbeiten,* II., 1879, p. 282.
[4] "Osmotische Untersuchungen," 1877, p. 202.

a certain insight into the reactions of plants which we should not otherwise possess. This is, I allow, a very dangerous tendency, leading to anthropomorphism, one of the seven deadly sins of science. Nevertheless, it is one that must be used unless the great mass of knowledge accumulated by psychologists is to be forbidden ground to the physiologist.

Jennings[5] has admirably expressed the point of view from which we ought to deal with the behavior of the simpler organisms. He points out that we must study their movements in a strictly objective manner: that the same point of view must be applied to man, and that any resemblances between the two sets of phenomena are not only an allowable but a necessary aid to research.

What, then, are the essential characters of stimuli and of the reactions which they call forth in living organisms? Pfeffer has stated this in the most objective way. An organism is a machine which can be set going by touching a spring or trigger of some kind; a machine in which energy can be set free by some kind of releasing mechanism. Here we have a model of at least some of the features of reaction to stimulation.

The energy of the cause is generally out of all proportion to the effect, *i. e.*, a small stimulus produces a big reaction. The specific character of the result depends on the structure of the machine rather than on the character of the stimulus. The trigger of a gun may be pulled in a variety of different ways without affecting the character of the explosion. Just in the same way a plant may be made to curve by altering its angle to the vertical, by lateral illumination, by chemical agency, and so forth; the curvature is of the same nature in all cases, the release-action differs. One of those chains of wooden bricks in which each knocks over the next may be set in action by a touch, by throwing a ball, by an erring dog, in short by anything that upsets the equilibrium of brick No. 1; but the really important part of the game, the way in which the wave of falling bricks passes like a prairie fire round a group of Noah's Ark animals, or by a bridge over its own dead body and returns to the starting-point, etc.—these are the result of the magnificent structure of the thing as a whole, and the upset of brick No. 1 seems a small thing in comparison.

For myself I see no reason why the term *stimulus* should not be used in relation to the action of mechanisms in general; but by a convention which it is well to respect, *stimulation* is confined to the protoplasmic machinery of living organisms.

The want of proportion between the stimulus and the reply, or, as it has been expressed, the unexpectedness of the result of a given stimulus, is a striking feature in the phenomena of reaction. That this should be so need not surprise us. We can, as a rule, only know the stimulus and the response, while the intermediate processes of the mechanism are hidden in the secret life of protoplasm. We might, however, have guessed that big changes would result from small stimuli, since it is clear that the success of an organism in the world must depend partly at least on its being highly sensitive to changes in its surroundings. This is the adaptive side of the fundamental fact that living protoplasm is a highly unstable body. Here I may say one word about the adaptation as treated in the "Origin of Species." It is the present fashion to minimize or deny altogether the importance of natural selection. I do not propose to enter into this subject; I am convinced that the inherent

[5] "The Behavior of the Lower Organisms," 1904, p. 124.

strength of the doctrine will insure its final victory over the present anti-Darwinian stream of criticism. From the Darwinian point of view it would be a remarkable fact if the reactions of organisms to natural stimuli were not adaptive. That they should be so, as they undoubtedly are, is not surprising. But just now I only call attention to the adaptive character of reactions from a descriptive point of view.

Hitherto I have implied the existence of a general character in stimulation without actually naming it; I mean the indirectness of the result. This is the point of view of Dutrochet, who in 1824 said that the environment suggests but does not directly cause the reaction. It is not easy to make clear in a few words the conception of indirectness. Pfeffer[6] employs the word *induction*, and holds that external stimuli act by producing internal change, such changes being the link between stimulus and reaction. It may seem, at first sight, that we do not gain much by this supposition; but since these changes may be more or less enduring, we gain at least the conception of *after effect* as a quality of stimulation. What are known as *spontaneous* actions must be considered as due to internal changes of unknown origin.

It may be said that in speaking of the "indirectness" of the response to stimuli we are merely expressing in other words the conception of release-action; that the explosion of a machine is an indirect reply to the touch on the trigger. This is doubtless true, but we possibly lose something if we attempt to compress the whole problem into the truism that the organism behaves as it does because it has a certain structure. The quality of indirectness is far more characteristic of an organism than of a machine, and to keep it in mind is more illuminating than a slavish adherence to the analogy of a machine. The reaction of an organism depends on its past history; but, it may be answered, this is also true of a machine the action of which depends on how it was made, and in a less degree on the treatment it has received during use. But in living things this last feature in behavior is far more striking, and in the higher organisms past experience is all-important in deciding the response to stimulus. The organism is a plastic machine profoundly affected in structure by its own action, and the unknown process intervening between stimulus and reaction (on which the indirectness of the response depends) must have the fullest value allowed it as a characteristic of living creatures.

For the zoological side of biology a view similar to that of Pfeffer has been clearly stated by Jennings[7] in his admirable studies on the behavior of infusoria, rotifers, etc. He advances strong arguments against the theories of Loeb and others, according to which the stimulus acts directly on the organs of movement; a point of view which was formerly held by botanists, but has since given place to the conception of the stimulation acting on the organism as a whole. Unfortunately for botanists these movements are by the zoologists called *tropisms*, and are thus liable to be confused with the geotropism, heliotropism, etc., of plants: to these movements, which are not considered by botanists to be due to direct action of stimuli, Loeb's assumptions do not seem to be applicable.

Jennings's position is that we must take into consideration what he calls "physiological state, *i. e.*, 'the varying internal physiological conditions of the organism,

[6] "Physiology," English edition, I., p. 11.

[7] H. S. Jennings, "Contributions to the Study of the Behavior of the Lower Organisms," Carnegie Institution, 1904, p. 111.

as distinguished from permanent anatomical conditions.' '' Though he does not claim novelty for his view, I am not aware that it has ever been so well stated. External stimuli are supposed to act by altering this physiological state; that is, the organism is temporarily transformed into what, judged by its reactions, is practically a different creature.

This may be illustrated by the behavior of *Stentor,* one of the fixed infusoria.[8] If a fine jet of water is directed against the disc of the creature, it contracts ''like a flash'' into its tube. In about half a minute it expands again and the cilia resume their activity. Now we cause the current to act again upon the disc. This time the *Stentor* does not contract, which proves that the animal has been in some way changed by the first stimulus. This is a simple example of ''physiological state.'' When the *Stentor* was at rest, before it received the first current of water, it was in state 1, the stimulus changed state 1 into state 2, to which contraction is the reaction. When again stimulated it passed into state 3, which does not produce contraction.

We can not prove that the contraction which occurred when the *Stentor* was first stimulated was due to a change of state. But it is a fair deduction from the result of the whole experiment, for after the original reaction the creature is undoubtedly in a changed state, since it no longer reacts in the same way to a repetition of the original stimulus.

Jennings points out that, as in the case of plants, spontaneous acts are brought about when the physiological state is changed by unknown causes, whereas in other cases we can point to an external agency by which the same result is effected.

[8] Jennings, " Behavior of the Lower Organisms," 1906, p. 170.

MORPHOLOGICAL CHANGES

Let us pass on to the consideration of the permanent or morphological changes and the stimuli by which they are produced, a subject to which, in recent years, many workers have devoted themselves. I need only mention the names of Vöchting, Goebel and Klebs, among botanists, and those of Loeb, Herbst and Driesch among zoologists, to remind you of the type of research to which I refer.

These morphological alterations produced by changes in environment have been brought under the rubric of reaction to stimulation, and must be considered as essentially similar to the class of temporary movements of which I have spoken.

The very first stage in development may be determined by a purely external stimulus. Thus the position of the first cell-wall in the developing spore of *Equisetum* is determined by the direction of incident light.[9] In the same way the direction of light settles the plane of symmetry of *Marchantia* as it develops from the gemma.[10] But the more interesting cases are those where the presence or absence of a stimulus makes an elaborate structural difference in the organism. Thus, as Stahl[11] has shown, beech leaves developed in the deep shade of the middle of the tree are so different in structure from leaves grown in full sunlight that they would unhesitatingly be described as belonging to different species. Another well-known case is the development of the scale-leaves on the rhizome of *Circæa* into the foliage leaves under the action of light.[12]

The power which the experimenter has over the lower plants is shown by Klebs, who kept *Saprolegnia mixta,* a fungus found on dead flies, in uninterrupted veg-

[9] Stahl, *Ber. d. Bot. Ges.,* 1885, p. 334.
[10] Pfeffer, in Sachs's *Arbeiten,* I., p. 92.
[11] *Jenaische Zeitschr.,* 1883, p. 162.
[12] Goebel, in *Bot. Zeitung,* 1880.

etative growth for six years; while by removing a fragment of the plant and cultivating it in other conditions the reproductive organs could at any time be made to appear.[13]

Chlamydomonas media, a unicellular green alga, when grown in a 0.4 per cent. nutrient solution, continues to increase by simple division, but conjugating gametes are formed in a few days if the plant is placed in pure water and kept in bright light.[14] Numberless other cases could be given of the regulation of form in the lower organisms. Thus *Sporodinia* grown on peptone-gelatine produces sporangiferous hypha, but on sugar zygotes are formed. Again, *Protosiphon botryoides,* if grown on damp clay, can most readily be made to produce spores by transference to water either in light or in darkness. But for the same plant cultivated in Knop's solution the end can best be obtained by placing the culture in the dark.[15] Still these instances of the regulation of reproduction are not so interesting from our point of view as some of Klebs's later results.[16] Thus he has shown that the color of the flower of *Campanula trachelium* can be changed from blue to white and back again to blue by varying the conditions under which the plant is cultivated. Again, with *Sempervivum*[17] he has been able to produce striking results —*e. g.*, the formation of apetalous flowers with one instead of two rows of stamens. Diminution in the number of stamens is a common occurrence in his experimental plants, and absolute loss of these organs also occurs. Many other abnormalities were induced, both in the stamens and in other parts of the flowers.

[13] *Willkürliche Entwick.*, p. 27.

[14] Klebs, *Bedingungen*, 1896, p. 430.

[15] *Biol. Centralbl.*, 1904, pp. 451–3.

[16] *Jahrb. f. wiss. Bot.*, XLII., 1906, p. 162.

[17] *Abhandl. Naturforsch. Ges. zu Halle,* XXV., 1906, pp. 31, 34, etc.

There is nothing new in the character of these facts;[18] what has been brought to light (principally by the work of Klebs) is the *degree* to which ontogeny is controllable. We are so much in the habit of thinking of the stable element in ontogeny that the work of Klebs strikes us with something of a shock. Most people would allow that change of form is ultimately referable to changed conditions, but many of us were not prepared to learn the great importance of external stimuli in ontogeny.

Klebs begins by assuming that every species has a definite *specific structure,* which he compares to chemical character. Just as a substance such as sulphur may assume different forms under different treatment, so he assumes that the specific structure of a plant has certain potentialities which may be brought to light by appropriate stimuli. He divides the agencies affecting the structure into external and internal conditions, the external being supposed to act by causing alterations in the internal conditions.

It will be seen that the scheme is broadly the same as that of Pfeffer for the case of the movement and other temporary reactions. The internal conditions of Klebs correspond also to the "physiological state" of Jennings.

From what has gone before, it will be seen that the current conception of stimulus[19] is practically identical, whether we

[18] See the great collection of facts illustrating the "direct and definite action of the external conditions of life" in "Variation of Animals and Plants," II., p. 271.

[19] With regard to the terminology of stimulation, I believe that it would greatly simplify matters if our classification of causal conditions could be based on the relation of the nucleus to the rest of the cell. But our knowledge does not at present allow of more than a tentative statement of such a scheme. It is now widely believed that the nucleus is the bearer of the qualities transmitted from generation to generation, and the regulator of ontogeny. May we not, therefore,

look at the phenomena of movement or those of structure. If this is allowable—and the weight of evidence is strongly in its favor—a conclusion of some interest follows.

If we reconsider what I have called the indirectness of stimulation, we shall see that it has a wider bearing than is at first obvious. The "internal condition" or "physiological state" is a factor in the regulation of the organism's action, and it is a factor which owes its character to external agencies which may no longer exist.

The fact that stimuli are not momentary in effect but leave a trace of themselves on the organism is in fact the physical basis of the phenomena grouped under memory in its widest sense as indicating that action is regulated by past experience. Jennings[20] remarks: "In the higher animals, and especially in man, the essential features in behavior depend very largely on the history of the individual; in other words, upon the present physiological condition of the individual, as determined by the stimuli it has received and the reactions it has performed. But in this respect the higher animals do not differ in principle, but only in degree, from the lower organisms. . . ." I venture to believe that this is true of plants as well as of animals, and that it is further broadly true not only of physiological behavior, but of the changes that are classed as morphological.

Semon in his interesting book, "Die Mneme,"[21] has used the word *Engram* for the trace or record of a stimulus left on the organism. In this sense we may say that the internal conditions of Pfeffer, the physiological states of Jennings and the internal conditions of Klebs are, broadly speaking, *Engrams*. The authors of these theories may perhaps object to this sweeping statement, but I venture to think it is broadly true.

The fact that in some cases we recognize the chemical or physical character of the internal conditions does not by any means prevent our ascribing a *mnemic* memory-like character to them, since they remain causal agencies built up by external conditions which have, or may have, ceased to exist. Memory will be none the less memory when we know something of the chemistry and physics of its neural concomitant.

consider it probable that the nucleus plays in the cell the part of a central nervous system? In plants there is evidence that the ectoplasm is the sensitive region, and, in fact, plays the part of the cell's sense-organ. The change that occurs in the growth of a cell, as a response to stimulus, would on this scheme be a reflex action dependent for its character on the structure of the nucleus. The "indirectness" of stimulation would then depend on the reception by the nucleus of the excitation set up in the ectoplasm, and the secondary excitation reflected from the nucleus, leading to certain changes in the growth of the cell.

If the nucleus be the bearer of the past history of the individual, the scheme here sketched would accord with the adaptive character of normal reactions and would fall into line with what we know of the regulation of actions in the higher organisms. Pfeffer ("Physiology of Plants," Eng. trans., III., p. 10) has briefly discussed the possibility of thus considering the nucleus as a reflex center, and has pointed out difficulties in the way of accepting such a view as universally holding good. Delage ("L'Hérédité," 2d edition, 1903, p. 88) gives a good summary of the evidence which induces him to deny the mastery of the cell by the nucleus. Driesch, however ("Analytische Theorie der organischen Entwicklung," 1894, p. 81), gives reasons for believing that the cytoplasm is the receptive region, while the nucleus is responsible for the reaction, and it is on this that he bases his earlier theory of ontogeny.

[20] P. 124 (1904).

[21] "Die Mneme, als erhaltendes Prinzip im Wechsel des organischen Geschehens," von Richard Semon, 1te Auflage, Leipzig, 1904; 2te Auflage, 1908. It is a pleasure to express my indebtedness to this work, as well as for the suggestions and criticisms which I owe to Professor Simon personally.

HABIT ILLUSTRATED BY MOVEMENT

In order to make my meaning plain as to the existence of a *mnemic* factor in the life of plants, I shall for the moment leave the morphological side of life and give an instance of habitual movement.

Sleeping plants are those in which the leaves assume at night a position markedly different from that shown by day. Thus the leaflets of the scarlet-runner (*Phaseolus*) are more or less horizontal by day and sink down at night. This change of position is known to be produced by the alternation of day and night. But this statement by no means exhausts the interest of the phenomenon. A sensitive photographic plate behaves differently in light and darkness; and so does a radiometer, which spins by day and rests at night.

If a sleeping-plant is placed in a dark room after it has gone to sleep at night, it will be found next morning in the light-position, and will again assume the nocturnal position as evening comes on. We have, in fact, what seems to be a habit built by the alternation of day and night. The plant normally drops its leaves at the stimulus of darkness and raises them at the stimulus of light. But here we see the leaves rising and falling in the absence of the accustomed stimulation. Since this change of position is not due to external conditions it must be the result of the internal conditions which habitually accompany the movement. This is the characteristic *par excellence* of habit—namely, a capacity, acquired by repetition, of reacting to a fraction of the original environment. We may express it in simpler language. When a series of actions is compelled to follow each other by applying a series of stimuli they become organically tied together, or *associated,* and follow each other automatically, even when the whole series of stimuli are not acting. Thus in the formation of habit *post hoc* comes to be equivalent to *propter hoc.* Action B automatically follows action A, because it has repeatedly been compelled to follow it.

This may be compared with Herbert Spencer's[22] description of an imaginary case, that of a simple aquatic animal which contracts its tentacles on their being touched by a fish or a bit of seaweed washed against it. If such a creature is also sensitive to light the circumstances under which contraction takes place will be made up of two stimuli—those of light and of contact—following each other in rapid succession. And, according to the above statement of the essential character of associative habit, it will result that the light-stimulus alone may suffice, and the animal will contract without being touched.

Jennings[23] has shown that the basis of memory by association exists in so low an organism as the infusorian *Stentor.* When the animal is stimulated by a jet of water containing carmine in suspension, a physiological state A is produced, which, however, does not immediately lead to a visible reaction. As the carmine stimulus is continued or repeated, state B is produced, to which the *Stentor* reacts by bending to one side. After several repetitions of the stimulus, state C is produced, to which the animal responds by reversing its ciliary movement, and C finally passes into D, which results in the *Stentor* contracting into its tube. The important thing is that after many repetitions of the above treatment the organism "contracts at once as soon as the carmine comes in contact with it." In other words, states B and C are apparently omitted, and A passes directly into D, *i. e.,* into the state which gives contraction as a reaction. Thus we have in

[22] "Psychology," 2d edition, 1870, Vol. I., p. 435.

[23] "Behavior of the Lower Organisms," 1906, p. 289.

an infusorian a case of short-circuiting precisely like the case which has been quoted from Herbert Spencer as illustrating association. But Jennings's case has the advantage of being based on actual observation. He generalizes the result as the "law of the resolution of physiological states" in the following words: "The resolution of one physiological state into another becomes easier and more rapid after it has taken place a number of times." He goes on to point out that the operation of this law is seen in the higher organisms, "in the phenomena which we commonly call memory, association, habit-formation, and learning."

In spite of this evidence of mnemic power in the simplest of organisms, objections will no doubt be made to the statement that association of engrams can occur in plants.

Pfeffer, whose authority none can question, accounts for the behavior of sleeping plants principally on the more general ground that when any movement occurs in a plant there is a tendency for it to be followed by a reversal—a swing of the physiological pendulum in the other direction. Pfeffer[24] compares it to a released spring which makes several alternate movements before it settles down to equilibrium. But the fact that the return movements occur at the same time-intervals as the stimuli is obviously the striking feature of the case. If the pendulum-like swing always tended to occur naturally in a twelve-hours' rhythm it would be a different matter. But Pfeffer has shown that a rhythm of six hours can equally well be built up. And the experiments of Miss Pertz and myself[25] show that a half-hourly or quarter-hourly rhythm can be produced by alternate geotropic stimulation.

We are indebted to Keeble[26] for an interesting case of apparent habit among the lower animals. *Convoluta roscoffensis,* a minute wormlike creature found on the coast of Brittany, leads a life dependent on the ebb and flow of the sea. When the tide is out the *Convoluta* come to the surface, showing themselves in large green patches. As the rising tide begins to cover them they sink down into safer quarters. The remarkable fact is that when kept in an aquarium, and therefore removed from tidal action, they continue for a short time to perform rhythmic movements in time with the tide.

Let us take a human habit, for instance that of a man who goes a walk every day and turns back at a given mile-post. This becomes habitual, so that he reverses his walk automatically when the limit is reached. It is no explanation of the fact that the stimulus which makes him start from home includes his return—that he has a mental return-ticket. Such explanation does not account for the point at which he turns, which as a matter of fact is the result of association. In the same way a man who goes to sleep will ultimately wake; but the fact that he wakes at four in the morning depends on a habit built up by his being compelled to rise daily at that time. Even those who will deny that anything like association can occur in plants can not deny that in the continuance of the nyctitropic rhythm in constant conditions we have, in plants, something which has general character of habit, *i. e.,* a rhythmic action depending on a rhythmic stimulus that has ceased to exist.

On the other hand, many will object that even the simplest form of association implies a nervous system. With regard to

[24] See Pfeffer, *Abhandl. K. Sächs. Ges.,* Bd. XXX., 1907. It is impossible to do justice to Pfeffer's point of view in the above brief statement.

[25] *Annals of Botany,* 1892 and 1903.

[26] Gamble and Keeble, *Quar. Jour. Micros. Sci.,* XLVII., p. 401.

this objection it must be remembered that plants have two at least of the qualities characteristic of animals—namely, extreme sensitiveness to certain agencies and the power of transmitting stimuli from one part to the other of the plant body. It is true that there is no central nervous system, nothing but a complex system of nuclei; but these have some of the qualities of nerve cells, while intercommunicating protoplasmic threads may play the part of nerves. Spencer[27] bases the power of association on the fact that every discharge conveyed by a nerve "leaves it in a state for conveying a subsequent like discharge with less resistance." Is it not possible that the same thing may be as true of plants as it apparently is of infusoria? We have seen reasons to suppose that the "internal conditions" or "physiological states" in plants are of the nature of engrams, or residual effects of external stimuli, and such engrams may become associated in the same way.

There is likely to be another objection to my assumption that a simple form of associated action occurs in plants—namely, that association implies consciousness. It is impossible to know whether or not plants are conscious; but it is consistent with the doctrine of continuity that in all living things there is something psychic, and if we accept this point of view we must believe that in plants there exists a faint copy of what we know as consciousness in ourselves.[28]

I am told by psychologists that I must define my point of view. I am accused of occupying that unscientific position known as "sitting on the fence." It is said that, like other biologists, I try to pick out what suits my purpose from two opposite schools of thought—the psychological and the physiological.

[27] "Psychology," 2d edition, Vol. I., p. 615.

[28] See James Ward, "Naturalism and Agnosticism," Vol. I., Lecture X.

What I claim is that, as regards reaction to environment, a plant and a man must be placed in the same great class, in spite of the obvious fact that as regards complexity of behavior the difference between them is enormous. I am not a psychologist, and I am not bound to give an opinion as to how far the occurrence of definite actions in response to stimulus is a physiological and how far a psychological problem. I am told that I have no right to assume the neural series of changes to be the cause of the psychological series, though I am allowed to say that neural changes are the universal concomitants of psychological change. This seems to me, in my ignorance, an unsatisfactory position. I find myself obliged to believe that the mnemic quality in all living things (which is proved to exist by direct experiment) must depend on the physical changes in protoplasm, and that it is, therefore, permissible to use these changes as a notation in which the phenomena of habit may be expressed.

(To be concluded)

Francis Darwin

DOCTORATES CONFERRED BY AMERICAN UNIVERSITIES

The accompanying table gives the number of doctorates of philosophy and science conferred this year and during the preceding ten years by forty-two institutions. In the issue of Science for August 30, 1907, will be found the details for the earlier years. The numbers for the eleven years have been as follows: 236, 224, 239, 255, 224, 270, 289, 325, 326, 327, 366. There has thus been a considerable though irregular increase. Unless the number this year is a chance fluctuation, it represents a gain of 12 per cent. above last year and of 50 per cent. above the figures for six or eight years ago.

Columbia and Chicago gave more degrees, 55 and 54, respectively, than have ever before been granted by any institu-

tion in one year. There is no noticeable alteration in the standing of the different universities. Wisconsin has maintained the large advance made last year, and Illinois has conferred five degrees, not a large number, but equal to the total of the preceding ten years. Probably the most important educational advance of the next ten years will be the growth of advanced and research work in the great state universities of the central and western states.

Of 3,093 degrees conferred in the eleven years, 1,416, nearly half, have been in the natural and exact sciences. As shown in Table II., there were this year 184 degrees in these sciences, a gain of 41 over last year. Chicago gave 37 of these degrees, twice as many as any other institution, and takes the position at the head

TABLE I

Doctorates Conferred

	Average of 10 Years 1898–1907	1908	Total for 11 Years 1898–1908
Chicago	35.6	54	410
Harvard	33.8	42	380
Columbia	32.2	55	377
Yale	31.8	32	350
Johns Hopkins	30.5	28	333
Pennsylvania	22.5	32	257
Cornell	18.1	22	203
Wisconsin	8.6	17	103
Clark	8.7	11	98
New York	6.7	15	82
Michigan	6.9	4	73
Boston	4.4	11	55
California	3.3	4	37
Princeton	2.6	6	32
Virginia	2.8	4	32
George Washington	2.8	3	31
Minnesota	2.4	3	27
Brown	2.3	2	25
Bryn Mawr	2.1	4	25
Nebraska	2.0	2	22
Catholic	2.0	1	21
Stanford	1.4	2	16
Iowa	1.1	2	13
Georgetown	1.0	0	10
Illinois	.5	5	10
Washington	.7	1	8
Missouri	.4	3	7
Vanderbilt	.6	1	7
Massachusetts Institute	.3	3	6
Colorado	.5	0	5
North Carolina	.5	0	5
Pittsburg	.1	4	5
Washington and Lee	.4	1	5
Northwestern	.4	0	4
Cincinnati	.3	0	3
Indiana	.0	3	3
Kansas	.3	0	3
Lafayette	.3	0	3
Dartmouth	.1	1	2
Lehigh	.2	0	2
Syracuse	.2	0	2
Tulane	.1	0	1
Total	271.5	378	3,093

TABLE II

Doctorates Conferred in the Sciences

	Average of 10 Years 1898–1907	1908	Total for 11 Years 1898–1908	Per Cent.
Chicago	16.4	37	201	49
Johns Hopkins	16.8	17	185	56
Columbia	13.4	21	155	41
Harvard	14.1	13	154	41
Yale	12.4	16	140	40
Cornell	10.4	15	119	59
Pennsylvania	9.0	18	108	42
Clark	7.7	11	88	90
Wisconsin	2.8	6	34	33
Michigan	2.9	1	29	40
California	2.4	2	26	70
George Washington	1.7	2	19	61
Brown	1.2	2	14	56
Nebraska	1.3	1	14	64
Princeton	1.1	3	14	43
Stanford	1.1	2	13	81
Virginia	1.1	2	13	41
Bryn Mawr	1.0	1	11	44
Minnesota	.7	1	8	30
Washington	.7	1	8	100
Iowa	.7	0	7	54
New York	.6	1	7	9
Massachusetts Institute	.3	3	6	100
Catholic	.5	(b)	5	25
Missouri	.3	2	5	71
Vanderbilt	.3	1	4	57
Washington and Lee	.3	1	4	80
Illinois	.3	0	3	30
Indiana	.0	3	3	100
Kansas	.3	0	3	100
North Carolina	.3	0	3	60
Colorado	.2	0	2	40
Dartmouth	.1	1	2	100
Lehigh	.2	0	2	100
Northwestern	.2	0	2	50
Boston	.1	0	1	2
Cincinnati	.1	0	1	33
Georgetown	.1	0	1	10
Lafayette	.1	0	1	33
Syracuse	.1	0	1	50
Total	123.2	184	1,416	46

of the list hitherto held by Johns Hopkins. Columbia with 21 degrees takes the third place, held last year by Harvard. Pennsylvania, with 18 degrees, much exceeds any previous year, and Yale and Cornell with 16 and 15 degrees, respectively, surpass their records in all but one year. Harvard and Johns Hopkins, on the other hand, show losses. These figures have, however, no considerable significance, as chance fluctuations of this size are likely to occur. The last column shows the percentages of the degrees which were in the sciences, there being considerable differences in the different institutions. Thus at Cornell and Johns Hopkins nearly 60 per cent. of the degrees are in the sciences, whereas, at Harvard, Yale and Columbia the percentage is about forty. At Clark it is ninety; at New York University it is nine and at Boston University two.

TABLE III

	Average of 10 Years 1898–1907	1908	Total for 11 Years 1898–1908
Chemistry	32.0	54	374
Physics	15.5	22	177
Zoology	14.7	25	172
Psychology	13.4	23	157
Mathematics	12.1	23	144
Botany	12.6	11	137
Geology	7.1	5	76
Physiology	4.1	7	48
Astronomy	3.4	1	35
Paleontology	1.6	1	17
Bacteriology	1.4	1	15
Anthropology	1.0	4	14
Agriculture	1.0	2	12
Anatomy	.9	2	11
Engineering	.8	0	8
Mineralogy	.6	0	6
Pathology	.5	2	7
Metallurgy	.3	0	3
Geography	.1	1	2
Meteorology	.1	0	1
Total	123.2	184	1,416

In Table III. the details for the several sciences are given. Chemistry shows a marked increase over any preceding year with as usual about double as many degrees as physics and zoology. Psychology, mathematics and botany follow closely, and there is then a drop to geology, physiology and astronomy. As has been noted in previous reports no strict line can be drawn between the natural and exact sciences, on the one hand, and philosophy, history and the languages, etc., on the other. The scientific method is increasingly applied in these subjects, and this tendency is probably more evident in the doctors' theses than elsewhere. The number of degrees given in these subjects this year was as follows: History, 32; English, 30; philosophy, 25; economics, 17; Germanic languages, 14; Romance languages, 12; Greek, 13; Latin, 12; Oriental languages, 9; political science, 9; education, 6; theology, 7; sociology, 6; law, 1; music, 1.

The institutions which led this year in conferring degrees in the different sciences were as follows: In *chemistry,* Chicago, Johns Hopkins and Pennsylvania, 7 each; in *physics,* Johns Hopkins 7, Yale 6; in *zoology,* Chicago 6, Pennsylvania 5; in *psychology,* Clark 6, Chicago and Columbia 5; in *botany,* Chicago 5; in *mathematics,* Chicago 6, Yale 4; in *geology,* Yale 3.

The names of those on whom the degree was conferred in the natural and exact sciences, with the subjects of their theses, are as follows:

UNIVERSITY OF CHICAGO

Edith Ethel Barnard: "The Effect of Electrolytes and Non-electrolytes on the Catalysis of Imido Esters."

Katharine Blunt: "A Study in Catalysis: The Formation of Amidines."

Robert Lacey Börger: "On the Determination of Ternary Linear Groups in a Galois Field of Order p^2."

Willey Denis: "On the Behavior of Various Aldehydes, Ketones and Alcohols toward Oxidizing Agents."

June Etta Downey: "Control Processes in

Handwriting; An Experimental Study of Verbal Imagery."

Grace Maxwell Fernald: "The Phenomena of Peripheral Vision as affected by the Brightness of Background and by Dark Adaptation."

Robert Anderson Hall: "A Study in Catalysis: The Formation of Guanidines from Isourea Esters."

Louis Ingold: "Vector Interpretation of Symbolic Parameters."

Nels Johann Lennes: "Curves in Non-metrical Analysis Situs with Applications to the Calculus of Variations and Differential Equations."

Frederick William Owens: "The Introduction of Ideal Elements and Construction of Projective n-space in Terms of a Planar System of Points involving Order and Desargues's Theorem."

Lula Pace: "Fertilization in Cypripedium."

Joseph Peterson: "Ohm's Law in relation to some Secondary Phenomena of Hearing."

Frank Henry Pike: "The Resuscitation of the Respiratory and Other Bulbar Nervous Mechanisms, with special reference to the Question of their Automaticity."

William Horace Ross: "On the Relation between the Radioactivity and the Composition of Thorium and Uranium Minerals."

Louis Agassiz Test: "A Study in Catalysis; The Rearrangement of Ortho-aminophenyl Esters."

Norman Richard Wilson: "Isoperimetrical Problems which are Reducible to Non-isoperimetrical Problems."

George Winchester: "The Effect of Temperature upon the Discharge of Electricity from Metals illuminated by Ultra-violet Light."

Oliver Charles Clifford: "Determination of the Susceptibility of Copper and Tin and their Alloys."

Frederick Valentine Emerson: "The Geographic Interpretation of New York City."

Louis Allen Higley: "The Action of Sodium and of Sodium Alcoholates on Various Esters of Acetic Acid."

Edwin Garvey Kirk: "The Histogenesis of Gastric Glands."

Frank Eugene Lutz: "The Variations and Correlations of the Taxonomic Characters of Gryllus."

Roy Lee Moodie: "Contribution to a Monograph of the North American Extinct Amphibia."

Florence Ella Richardson: "A Study of Sensory Control in the Rat."

Mary Emily Sinclair: "On a Compound Discontinuous Solution connected with the Surface of Revolution of Minimum Area."

Charles Christopher Adams: "The Geographic Variations and Relations of Io."

Mary Blount: "The Early Development of the Pigeon's Egg from Fertilization to the Organization of the Periblast."

Leonas Lancelot Burlingame: "Staminate Cone of Podocarpus."

Wallace Craig: "Expression of the Emotions in the Pigeons."

Reginald Ruggles Gates: "A Study of Reduction in *Œnothera rubrinervis*."

Herbert Marcus Goodman: "Active and Passive Immunity to Diphtheria Toxin."

Leroy Harris Harvey: "The Prairie Grass Formation of Southeastern South Dakota."

John Thomas Patterson: "Gastrulation in the Pigeon's Egg."

Charles Houston Shattuck: "Origin of Heterospery in Marsilia."

Ralph Edward Sheldon: "The Olfactory Tracts and Centers in Fishes."

George Washington Tannreuther: "History of the Germ Cells and Early Embryology of Certain Aphids."

Clarence Stone Yoakum: "An Experimental Study of Mental Fatigue."

COLUMBIA UNIVERSITY

Warner Brown: "Time in English Verse Rhythm."

Frank G. Bruner: "The Hearing of Primitive Peoples."

Gertrude Simmons Burlingham: "A Study of the Larctariæ of the United States."

Elizabeth Buchanan Cowley: "Plane Curves of the Eighth Order having Two Fourfold Points with Distinct Tangents and no other Point Singularities."

Norman Edward Ditman: "Opsonins and Vaccines in Medicine and Surgery."

Claude Russell Fountain: "The Spherical Emission of a Righi Vibrator."

Sven Froeberg: "The Relation between the Magnitude of the Stimulus and the Time of Reaction."

Francis Marion Hamilton: "The Perceptual Factors in Reading."

Eric Higgins: "The Temperature Coefficient of the Weight of a Falling Drop as a Means of Estimating the Molecular Weight and the Critical Temperature of a Liquid."

Homer Doliver House: "North American Species of the Genus *Ipomœa*."

Elmer Ellsworth Jones: "A Comparison of

Mental States in the Horizontal and Vertical Positions of the Body."

Farel Louis Jouard: "3-Amino-*o*-Phthalic Acid and Certain of its Derivatives."

Robert Harry Lowie: "The Test-theme in North American Mythology."

Daniel Ralph Lucas: "Physiological and Pharmacological Studies of the Ureter (III.)."

Clarence Earl May: "Oxygen Ethers of the Type —N:C·(OR), derived from Certain Nitrogen Heterocycles."

Arnold William Meyer: "The Determination of Diastatic Power by the Saccharification of Soluble Starch."

Leighton B. Morse: "The Selective Reflection of Salts of Carbonic and other Oxygen Acids."

Matthew Steel: "The Influence of Magnesium Sulphate on Nitrogenous Catabolism in Dogs, with Special Reference to the Distribution of Nitrogen among the Constituents of the Urine."

Reston Stevenson: "The Weight of a Falling Drop and the Laws of Tate. The Determination of the Molecular Weights and Critical Temperature of Liquids by the Aid of Drop Weights."

Frederick Seymour Weingarten: "The Influence of Internal Hemorrhage on Chemical Changes in the Organism, with particular reference to Proteid Catabolism."

William Henry Welker: "Some Observations on the Excretion of Nitrogenous Substances in the Urine of Dogs under Conditions of Diminished Oxidation induced by Potassium Cyanide."

UNIVERSITY OF PENNSYLVANIA

William Milton Barr: "A Study of the Spectrum and Bromides of Columbium."

William Blum: (*A*) "Experiments on the Atomic Weight of Cadmium." (*B*) "Derivatives of Complex Inorganic Acids."

James Edmund Bryan: "A Statistical and Clinical Study of the Children in the Elementary Schools in the City of Camden, New Jersey, in the School Year 1905–6, with a view to determining the Extent and Conditions of Retardation."

George Gailey Chambers: "The Groups of Isomorphisms of the Abstract Groups of Order p^2q."

Harold Sellers Colton: "Some Effects of Environment on the Growth of *Lymnæa columella* Say."

Margaret Harris Cook: "Spermatogenesis in Lepidoptera."

Lloyd Cadie Daniels: "Some New Derivatives of Complex Inorganic Acids."

Harrison Hale: "An Electrolytic Method of Analyzing Zinc Ores."

Jacob Daniel Heilman: "A Clinical Study of One Thousand Retarded or Over-age Children in the Public Schools of Camden, New Jersey."

Mary Elizabeth Holmes: "The Use of the Rotating Anode in Electrolytic Separations."

Merkel Henry Jacobs: "The Effects of Desiccation on the Rotifer *Philodina roseola*."

George Irving Kemmerer: "The Atomic Weight of Palladium."

Jacob Buehrle Krause: "The Modification of the Reaction-time due to Variation of the Preparation."

Herbert Guy Kribs: "The Behavior of Æolosoma."

John Ahlum Schaeffer: "Double Fluorides of Titanium."

Frank Gouldsmith Speck: "Ethnology of the Yuchi Indians."

Charles Vuilleumier: "The Distribution of the Values of Reactions to Sound in Twenty-four Hundred Consecutive Reactions with Each of Four Subjects."

Louise Baird Wallace: "The Spermatogenesis of *Agalena nævia*."

JOHNS HOPKINS UNIVERSITY

Marshall Perley Cram: "The Fractionation of Crude Petroleum by Capillary Filtration."

Ernest Elisha Gorsline: "A Study of the Claisen Condensation."

John Sharshall Grasty: "The Limestones of Maryland."

Lars Olai Grondahl: "Synchronous Commutation as a Method for Transformation from Alternating to Direct Current."

David Vance Guthrie: "The Ultra-violet Absorption Spectra of Certain Metallic Vapors and their Mixtures."

Felix Edward Walsh Hackett: "The Resonance and Magnetic Rotation Spectra of Sodium Vapor."

Herbert Eugene Ives: "An Experimental Study of the Lippmann Color Photograph."

Carl Alfred Jacobson: "The Conductivity and Ionization of Electrolytes in Aqueous Solutions as conditioned by Temperature, Dilution and Hydrolysis."

Edward G. Mahin: "Conductivity and Viscosity of Dilute Solutions of Lithium Nitrate and Cadmium Iodide, in Binary and Ternary Mixtures of Acetone with Methyl Alcohol, Ethyl Alcohol and Water."

Brainerd Mears: "The Osmotic Pressure of Cane Sugar Solutions at 15° Centigrade."

Harmon Vail Morse: "The Osmotic Pressure of Cane Sugar Solutions at 10°."

Edward Charles F. Phillips: "On the Pentacardioid."

Harvey Clayton Rentschler: "Dispersion of Gases."

William Frederick Schulz: "The Effect of a Magnetic Field upon the Absorption Spectra of Certain Rare Earths."

William Walker Strong: "Ionization in Closed Vessels."

James McIntosh Johnson: "Studies in Catalysis."

Ivey Foreman Lewis: "The Life History of *Griffithsia bornetiana*."

YALE UNIVERSITY

Stanley Rossiter Benedict: "Experimental Studies on the Metabolism of Magnesium and Calcium."

Earl Gordon Bill: "An Apriori Existence Theorem for Three Dimensions in the Calculus of Variations."

Theodore Harding Boggs: "The Influence exerted by the United Empire Loyalists on the Life and Politics of Nova Scotia and New Brunswick."

Walter Minor Bradley: "The Analysis and Chemical Composition of the Mineral Warwickite."

Samuel Hopkins Clapp: "Researches on Pyrimidine Derivatives."

William Allen Drushel: "The Quantitative Estimation of Potassium."

Frank Nugent Freeman: "The Habit of Handwriting and its Development, an Experimental Study."

Ruth Sawyer Harvey: "Drainage and Glaciation in the Central Housatonic Basin."

Frederick William Heyl: "Researches on Pyrimidines."

Francis Jerome Holder: "Multiple Series."

Francis Baker Laney: "The Gold Hill Mining District of North Carolina" (2 parts, texts and maps).

Ernest Barnes Lytle: "Multiple Integrals over Iterable Fields."

Howard Douglass Newton: "On some New Relations of Titanium in Analysis: The Volumetric Estimation of Titanium, of Iron in Presence of Titanium, and of Iron and Vanadium after Reduction with Titanous Sulphate."

Perry Blaine Perkins: "A Determination of the Molecular Weight of Radium Emanation by comparing its Rate of Diffusion with that of Mercury Vapor."

Freeman Ward: "Geology of the New Haven-Branford Region."

Euphemia Richardson Worthington: "Some Theorems on Surfaces."

CORNELL UNIVERSITY

Joseph Herschel Coffin: "An Analysis of the Action Consciousness based on the Simple Reaction."

Clyde Firman Craig: "On a Class of Hyperfuchsian Functions."

Herbert Grove Dorsey: "Coefficient of Linear Expansion at Low Temperatures."

Claude Wilbur Edgerton: "Studies on the Physiology and Development of some Anthracnoses."

Willard James Fisher: "The Temperature Coefficients of Gas Viscosity."

Percy Hodge: "An Experimental Study of Photo-active Cells with Fluorescent Electrolytes."

Reuben Edson Nyswander: "The Absorption and Reflection of Calcite and Aragonite for Infrared Rays as dependent upon the Plane of Polarization."

Clarence Albert Pierce: "Thermo-phosphorescence."

Carl George Schluederberg: "Actinic Electrolysis."

George Daniel Shafer: "Structure and Development of the Eyes of Certain Spiders."

John William Turrentine: "Contributions to the Chemistry of Hydrazine."

Anna Lavinia Van Benschoten: "The Birational Transformations of Algebraic Curves of Genus Four."

Paul J. White: "An Agricultural Survey of Tompkins County, New York."

Frances Gertrude Wick: "Some Electrical Properties of Silicon."

Albert Hazen Wright: "The Anura of Ithaca."

HARVARD UNIVERSITY

Percy Williams Bridgman: "Mercury Resistance as a Pressure Gauge."

Manton Copeland: "Spermatogenesis in Apis and Vespa."

Harry Louis Frevert: "Investigations in Chemical Thermodynamics."

Eliott Park Frost: "The Psychology and Correlation of Individual Differences."

Frank Irwin: "The Invariants of Linear Differential Expressions."

Grinnell Jones: (I.) "The Atomic Weights of Sulphur and Phosphorus." (II.) "The Compressibilities of certain Salts."

Joseph Abraham Long: "The Maturation of the Egg of the Mouse."

Joseph Howard Mathews: "A Study of Compressibility and its Relation to various other Physical Properties of certain Organic Compounds."

Charles Napoleon Moore: "On the Theory of Convergence Factors and some of its Applications."

Rollin Clarke Mullenix: "The Peripheral Terminations of the Eighth Cranial Nerve in Vertebrates, especially in Fishes."

Arthur Sperry Pearse: "The Reactions of Amphibians to Light."

Conrad Louis Benoni Shuddemagen: (I.) "The Demagnetizing Factors for Cylindrical Iron Rods." (II.) "A Study of Residual Charge in Dielectrics."

John Hunt Wilson: (I.) "A Revision of the Atomic Weight of Lead." (II.) "Energy Changes involved in the Dilution of Amalgams of Thallium, Indium and Tin."

CLARK UNIVERSITY

Ernest William Coffin: "On the Education of Backward Races."

Herbert Burnham Davis: "The Raccoon: A Study in Animal Intelligence."

Charles Wilson Easley: "Partial Vapor Tensions of Binary Mixtures."

Willis Lloyd Gard: "Some Neurological and Psychological Aspects of Shock."

James William Harris: "The Development of the Esthetic Interest in Children."

Newton Miller: "The Biology of the American Toad."

George Ordahl: "Rivalry; its Genetic Development and Pedagogy."

Caroline Amelia Osborne: "The Sleep of Infancy as related to Physical and Mental Growth."

William Louis Prager: "Steric Hindrances in Esterification."

Hermon Lester Slobin: "On Plane Quintic Curves."

Jesse Hayes White: "Relations of the Racial and Individual Social Instincts."

UNIVERSITY OF WISCONSIN

Alfred Newton Cook: "Phenyl Ether and some of its Derivatives."

Robert Wilhelm Hegner: "The Early Development of the Germ Glands of some Chrysomelid Beetles."

Warren DuPré Smith: "Coal Deposits of Batan Island."

Charles Austin Tibbals: "A Study of the Tellurides."

Charles Taylor Vorhies: "Studies on the Trichoptera of Wisconsin."

Henry Charles Wolff: "The Continuous Plane Motion of a Liquid bounded by Two Right Lines."

INDIANA UNIVERSITY

Walter Louis Hahn: "The Habits and Reactions of the Cave Bats."

Dennis Emerson Jackson: "Some Experimental Observations upon the Prolonged Existence of Adrenalin in the Blood."

Mrs. Effa Funk Muhse: "The Cutaneous Glands of the Toad."

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

George Alonzo Abbott: "A Physico-chemical Study of Ortho- and Pyro-phosphoric Acids and of their Sodium and Ammonium Salts."

Charles Angus Kraus: "Solutions of Metals in Non-metallic Solvents."

Edward Wight Washburn: "Ionic Hydration and True Transference Numbers."

PRINCETON UNIVERSITY

Fay Cluff Brown: "The Ions emitted from Platinum and their Kinetic Energy."

George MacFeely Conwell: "The 3-space P. G. (3, 2) and its Group."

Lionel Herman Duschak: "Studies of the Silver Coulometer."

BROWN UNIVERSITY

Maurice Louis Dolt: "The Action of Acetic Anhydride on para Methoxy Phenyl Propiolic Acid, and on Methylene Ether of 3-4 Dihydroxy Phenyl Propiolic Acid."

Philip Bardwell Hadley: "The Development and Behavior of the American Lobster."

UNIVERSITY OF CALIFORNIA

Samuel Alfred Barrett: "Pomo Indian Basketry."

James Grant Davidson: "Function of the Electrodes in Conduction through Flames and Gases."

GEORGE WASHINGTON UNIVERSITY

Frank Cummings Cook: "Phosphorus Metabolism Experiments."

Clara Southmayd Ludlow: "The Mosquitoes of the Philippine Islands; the Distribution of Certain Species and their Occurrence in Relation to the Incidence of Disease."

UNIVERSITY OF MISSOURI

Charles Brooks: "The Fruit Spot of Apples; a Morphological and Physiological Study."

Caroline McGill: "The Structure of Smooth Muscle in the Resting and in the Contracted Condition."

LELAND STANFORD JUNIOR UNIVERSITY

William Draper Harkins: "Papers on Smelter Smoke."

Mary Isabel McCracken: "Studies in Heredity."

UNIVERSITY OF VIRGINIA

William Allison Kepner: "The Nutrition of the Ovum of *Scolia dubia*."

John Jennings Luck: "The Structures of the Non-integrable Groups of Seven Parameters."

BRYN MAWR COLLEGE

Helen Elizabeth Schaeffer: "A Study of the Electric Spark in a Magnetic Field."

DARTMOUTH COLLEGE

Leland Griggs: "The Early Development of the Nervous System of Amblystoma."

UNIVERSITY OF MICHIGAN

John Serenus Bordner: "The Longitudinal Traction on the Formation of Mechanical Tissue in Plant Stems."

UNIVERSITY OF MINNESOTA

Henry Anton Erikson: "The Ionization of Gases at High Pressures."

UNIVERSITY OF NEBRASKA

Leroy Dey Swingle: "The Development of a Herpetonionadine Parasite of the Sheep-tick." "The Embryology of *Myosurus minimus*."

NEW YORK UNIVERSITY

Martin A. Rosanoff: "Determination of Chlorides and Bromides in the presence of Cyanides."

VANDERBILT UNIVERSITY

James Harrison Scarborough: "The Computation of the Orbit of Planet."

WASHINGTON UNIVERSITY

Henri Theodore Antoine Hus: "An Ideal Ecological Cross-section of the Mississippi River in the Vicinity of St. Louis, Mo."

WASHINGTON AND LEE UNIVERSITY

Mosby Garland Perrow: "Determination and Comparison of the Atomic Volume Contraction in the Isomorphous Series, $R'M'''(SO_4)_2 \cdot 12H_2O$ and $R_2'M''(SO_4)_2 \cdot 6H_2O$."

SCIENTIFIC NOTES AND NEWS

DR. L. H. BAILEY, of Cornell University, has consented to accept the chairmanship of the commission appointed by President Roosevelt to report upon the social and economic conditions of agricultural life.

OXFORD University will confer the degree of doctor of science on Professor Svante Arrhenius and on Dr. Vernon Harcourt on October 8, on the occasion of the celebration of the jubilee of the University Museum.

ON the occasion of the recent unveiling of the Bunsen monument at Heidelberg, honorary doctorates were conferred on Professor Adolf von Baeyer, and on Professor J. H. van't Hoff.

A COMMITTEE has been formed in England to present a national testimonial to Mr. Francis George Heath in recognition of his labors in arousing public interest in the preservation of open spaces, woods and forests.

THE staff of the Division of Pharmacology of the Hygienic Laboratory, Washington, D. C., has been enlarged by the following appointments: Dr. W. H. Schultz, formerly instructor in physiology and pharmacology, University of Missouri; Dr. Worth Hale, formerly instructor of pharmacology, University of Michigan; Dr. M. G. Motter, formerly professor of physiology at Georgetown University and secretary of the Board of Trustees of the United States Pharmacopœia, and Mr. W. I. Wilbert, formerly of the German Hospital, Philadelphia. The addition to the Hygienic Laboratory, provided for by congress a year ago, is nearing completion; it will enable the laboratory to extend its work considerably.

MR. GEORGE L. FAWCETT, for three years laboratory assistant in the United States Subtropical Laboratory at Miami, Florida, has been transferred to the Porto Rico Experiment Station at Mayaguez, where he is to be

plant pathologist. This promotion takes effect on September 15.

Dr. W. H. Willcox, lecturer at St. Mary's Hospital Medical School, London, has been appointed senior scientific analyst to the British Home Office in succession to the late Sir Thomas Stevenson.

Dr. Eric A. Nobbs has been appointed director of agriculture in Rhodesia. He was graduated in agricultural science at the University of Edinburgh in 1899 and for the last six years he has been agricultural assistant to the Cape government.

Dr. Heinrich Moritz has been appointed director of the Observatory of Rio de Janeiro.

Dr. von der Borne has been given charge of the earthquake station at Krietern, near Breslau.

Mr. Robert Newstead, the lecturer in economic entomology and parasitology in the Liverpool School of Tropical Medicine, will go to Jamaica in the first week of November to undertake the investigation of the ticks there responsible for certain diseases in animals, and of disease-bearing insects. He may be accompanied by a medical research investigator, whose duties would be to investigate indigenous diseases of the island.

Dr. Sven Hedin's family, at Stockholm, has received the following telegram from the secretary to the viceroy of India, dated Simla, August 31: "Dr. Sven Hedin is well after a hard and successful journey. He reaches Simla early in September and sends you hearty greetings."

In spite of a heavy sea, the *Pourquoi Pas* left Cherbourg, on August 31, for Madeira. Mme. Charcot and Mme. Waldeck-Rousseau will leave the vessel at Buenos Ayres.

On the occasion of the celebration of the fiftieth anniversary of the foundation of the University Museum, Oxford, a bust will be unveiled of the late Professor Weldon, who held the Linacre chair of comparative anatomy until his death in 1906.

Dr. Ernst Loeb, the botanist, has died at Berlin at the age of sixty-six years.

Dr. Max Rosenmund, professor of topog-

Dr. L. P. Barclay, formerly representing the Bausch and Lomb Optical Company, died on September 1, at the Loomis Sanatorium, Liberty, N. Y.

Dr. Henry Youle Hind died at Windsor, Nova Scotia, in August, at the age of eighty-five years. He was a native of Nottingham, England, but came to Canada in 1847, after receiving his education at Leipzig, Cambridge and in France. He was geologist to the Red River exploring expedition in 1857, and had charge of the Assiniboine and Saskatchewan expedition of the following year. He explored a part of Labrador in 1861, made a preliminary geological survey of New Brunswick in 1864, examined at a later date the gold districts of Nova Scotia, and explored mineral lands in Newfoundland in 1876.

According to the London *Times* active preparations have been in hand for some time past in England and in New Zealand for the despatch of relief food-supplies and equipment for Lieutenant Shackleton and his comrades to McMurdo Sound in the Antarctic regions, where they are wintering preparatory to the sledge journeys to the south, east and west at the beginning of October. The supplies from London were shipped to Lyttelton, New Zealand, by the Royal mail steamer *Paparoa,* on September 3, and from Liverpool by the steamship *Surrey,* where they will be put on board the *Nimrod;* but meats, butter, cheese, woolen goods, etc., will be procured in New Zealand. The *Nimrod* will take food-supplies for thirty-eight men for one year, to provide against the possibility of being frozen in. A number of firms have made the expedition presents of their own commodities. The *Nimrod* will leave Lyttelton for the Antarctic on December 1, and she is at present in dry dock in that port undergoing repairs. The *Nimrod* left Lieutenant Shackelton and his party in the best of health at McMurdo Sound base, 77½ degrees south latitude, on February 22, and she returned to Lyttelton. She successfully landed all the stores at the above base before sailing, viz.: portable house, 33 feet by 19 feet by 8 feet; acetylene gas plant; two years' food-supplies, equipment, ponies, dogs, motor-car, coal, oil, etc., in fact everything neces-

raphy at the Zurich Polytechnic School, has died at the age of fifty-one years.

sary to make their stay there warm and comfortable for the winter. Captain F. P. Evans, R.N.R., by permission of Sir James Mills, chairman of the Union Steamship Company, of New Zealand, will command the *Nimrod* on her voyage to the Antarctic. It is hoped that news from the Antarctic will be received about March or April, 1909.

A TELEPHONE line has been installed to provide means of communication between the Queen Margherita Observatory on the Gniffet Peak, on Monte Rosa, and the observatory lower down the mountain. The carrying out of this line entailed many difficulties; the higher observatory is 14,960 feet above the sea. This building is only open for two months each year in the middle of summer.

UNIVERSITY AND EDUCATIONAL NEWS

THE regents of the West Virginia University, at their meeting in June, voted an increase of 10 per cent. in the salaries of all members of the faculty above the rank of instructor.

THE Board of Education of New York City asks for $33,031,484.65 for the schools in the coming year, an increase of $6,258,521.06 over 1908. The increase of about $5,500,000 for this year is largely due to the proposed increase of teachers' salaries, this alone occasioning an increase in the budget of $3,273,-163.52. It is estimated that the increase in the number of pupils for 1909, will be nearly 25,000. To provide a teaching staff for the increased registration in the elementary schools alone will require employment of 9 men principals, 2 women principals, 3 male assistants to principals, 15 assistants to women principals, 102 men teachers, 636 women teachers, and 82 kindergartners, at a total additional expense of $136,315.47.

LEIPZIG UNIVERSITY will celebrate the five hundredth anniversary of its foundation in July of next year.

THE foundations of the new hall of engineering of the University of Nebraska have been completed, and work has begun on the superstructure. The sum appropriated for this building is approximately $100,000, and it is hoped to have it completed by the opening of the fall semester in 1909.

THE newspapers *Reich* and *St. Petersburger Zeitung*, have been fined $1,500 each for publishing articles criticizing the policies of Mr. Schwartz, the new minister of education. He is said to have issued an order that all university professors and instructors belonging to the constitutional democratic party should either renounce their political principles or give up their positions.

IT is reported that ten members of the faculty of the College of Physicians and Surgeons, San Francisco, have resigned.

PROFESSOR ARTHUR DEXTER BUTTERFIELD, for ten years professor of mathematics in the University of Vermont, has accepted a similar position in the Worcester (Mass.) Polytechnic Institute, from which he was graduated in 1892 and in which he was formerly instructor.

DR. GEORGE A. COE, professor of philosophy at the Northwestern University, has been appointed to a chair in the Union Theological Seminary, New York City.

DR. ERNST A. BESSEY, pathologist in the United States Department of Agriculture, for the past three years in charge of the United States Subtropical Laboratory of Miami, Florida, has been elected to the professorship of botany in the University of Louisiana, at Baton Rouge. He will assume his new duties on October 20.

LIEUT.-COLONEL BOURGEOIS, chief of the geodetic section of the French Army Geographical Service, has been appointed to the chair of astronomy and geodesy in the Paris École polytechnique, vacant by the resignation of M. Poincaré.

DISCUSSION AND CORRESPONDENCE

SCHAEBERLE AND GEOLOGICAL CLIMATES

TO THE EDITOR OF SCIENCE: In Professor Schaeberle's last communication to SCIENCE, June 5, p. 894, he makes the statement that "it now rests solely with the scientists to demonstrate, if possible, that some vital flaw exists in my (Schaeberle's) published work (upon the effective surface temperature of

the sun and the temperature of space); so long as this can not be done, 'most modern theories' of geological climate must certainly be regarded as 'upset,' *for these theories are based upon an adopted value for the temperature of space which is* (according to my [Schaeberle's] demonstration) *too great by nearly three hundred degrees of the centigrade scale* at the earth's distance from the sun, etc." (italics original).

Statements as sweeping as these in the columns of SCIENCE, as pointed out by Lane in answer to an earlier communication, appear to call for some comment for the benefit of those of your readers who are neither geologists nor astronomers. In answer it may be stated that an inspection of recent geological literature in the special mediums of geological publication shows that all articles dealing with actual details of geological climates are based *not upon considerations of the temperature of space,* but upon *detailed studies of the geological record.* It is the effort of modern theory upon ancient climates to meet this evidence and the lines of theory are determined by the definiteness and complexity of the facts to be explained rather than by any assumption in regard to the temperature of space.

A generation ago, when but little was definitely known in regard to geologic climates, theoretical calculations as to what conditions could, should, or would have prevailed at the base of the atmosphere, would have had some weight. At present a study of the stratigraphic record to find what actually were the conditions is much more definite and profitable. The results of such study have been to show an oscillation of widespread climatic conditions from glacial to torrid and from humid to semi-arid, or arid, reaching back to the very beginning of the sedimentary rocks; extreme oscillations of shorter period being superimposed upon others of more general character and æon-long in their duration. At times climates appear to have been widely uniform, a feature whose explanation has been sought in hypotheses of changes in character of lands, in ocean currents, in atmospheric composition, or in solar diameter. But at other times, as in the Permian, climates seem to have been distinctly local, though the geologic, or time, contrasts in climates have been in general more striking than the geographic, or space, variations. Perhaps the heaviest blow which has been struck recently at the older hypothesis of a simple climatic evolution from a primitive, uniform, torrid condition is found in the work of Coleman, who has presented the evidence of a glacial period practically at the beginning of the sedimentary record in North America. The advance of knowledge in regard to geological climates, as in so many other fields, has been away from simplicity toward complexity.

In view of these conclusions by well-qualified geologists Manson's hypothesis of an earth self-heated and protected by a cloud envelope until the Tertiary, which Schaeberle considers that he has demonstrated as a true theory, and which has recently been picturesquely written up by Percival Lowell for the *Century* magazine as the assured dictum of geology, must be regarded as in no measure adequate to explain the facts. If that hypothesis is not to be relegated to the scientific scrap heap it must either be very greatly modified or its supporters must break down the conclusions in regard to geologic climates which have made it unavailable as an explanation. Until this is done it must be regarded as an unsupported speculation.

It would also add definiteness to that hypothesis if its advocates would make it quantitative by stating the amount of thermal energy now actually delivered by the earth's interior to its surface in unit time, basing this calculation upon the thermal conductivity of rock and the temperature gradient. For applying the hypothesis to past times the favorable sub-hypothesis should be postulated of assuming that the earth is simply a cooling body unwarmed by radio-active or other internal activities, since this permits a more rapid delivery of heat in the past. For the purposes of such a calculation also, the surface may be assumed to have remained of

practically constant temperature, compared to the earth's interior; since by the terms of the hypothesis the soil has been the seat of living beings during much of the time of cooling.

Furthermore, the rate of outflow of heat is determined solely by the temperature difference on the two sides of a rock layer, and a cloud envelope could only retard such outflow through materially raising the temperature of the surface rock and diminishing the temperature difference on the two sides of the outer zone. This is something which, as shown above, has not taken place, and consequently the delivery of thermal energy from the interior to the surface of a cooling earth may be computed for any fraction of its age. The evolution of life must be restricted to the later portions of the hypothetical cooling process, since, as Lane has pointed out,[1] rocks seem to have been buried in early times to as great a depth as now without metamorphism, save where mashed or injected. To cite a specific instance—the Belt terrane of Montana and Idaho shows formations which were buried to a depth of several miles in pre-Cambrian times, now almost if not quite as unmetamorphic as the Triassic formations of the eastern United States.

The actual thermal energy per unit time now and in past times received from the earth's interior, thus computed, could be compared with that determined by measurement as received in unit time from the sun and without reference to the actual temperatures of either earth or sun. Even in spite of much error in regard to the fundamental constants, unless some surprising error in previous methods is developed, such a calculation would show the earth to contribute but a negligible fraction and would indicate to what an extent a hypothetical cloud envelope and early atmosphere of assumed composition would have to operate as an impermeable blanket to make up for the hypothetical deficiency in solar radiation. Having drawn this thermally opaque envelope about the earth, the Mansonians must next demonstrate how light was able to penetrate to permit the building up of vegetable protoplasm and give employment to the eyes of animals during the Paleozoic and Proterozoic ages.

JOSEPH BARRELL

[1] SCIENCE, April 10, 1908, p. 591.

QUOTATIONS

THE PUBLIC HEALTH

PROFESSOR WILLIAM T. SEDGWICK'S address on "The Call to Public Health" has been printed in a recent number of SCIENCE, and the perusal of it can not fail to be instructive and inspiring. The health of the public must necessarily be based upon the health of individuals, yet when one speaks of the public health he has in mind something much broader and much more important than the health of isolated members of the community. The public health means the health question socialized, and this broadening of the base so as to include whole populations has arisen from the conception, made vital by modern science, that the health of the individual immediately concerns his family, his neighbor and his city. There is a community of interests vitally affecting human life which makes the public health of importance to the municipality and the state; and, as Professor Sedgwick easily shows, this is a development that has come very late in modern civilization, and to-day calls for a greater degree of attention than has ever before been given to it.

A certain selfishness, or indifference to others, that has naturally resulted from the old individualism, has until recent years blinded the majority of people to the necessary relation between individual and public health. The main concern of the average man has been to keep himself and his family well; all others he had no interest in. He paid the doctor's bills for professional services in the family circle, and there his responsibility ended. Modern science has shaken this form of indifference by demonstrating the preventability of most contagious and infectious diseases. Epidemics have been studied enough to convince the average man that their spread in a normal, civilized community is nothing

less than a wanton massacre of the innocents. And the helplessness of the individual, even when attended by the best of medical practitioners, in contending alone with the general conditions which play havoc with the health of the most favored people, has convinced every one of knowledge and sense that the maintenance of the public health is a public function. As there is a community of interests at the bottom of the health question, so there must be community of effort.—*The Springfield Republican.*

SCIENTIFIC BOOKS

Rocks and Rock Minerals. A Manual of the Elements of Petrology without the Use of the Microscope. By Louis V. Pirsson. New York, John Wiley and Sons; London, Chapman and Hall. 12mo. Pp. 414, 74 figs., 36 plates.

Few if any petrologists are better qualified by reason of notable attainments in the science, as well as by long experience in teaching it, to write a manual of petrology than is Professor Pirsson, of Yale University, and it is with pleasure that we note the appearance of the book before us. Teachers of petrology will in general, we believe, fully agree with the author's opinion, as expressed in his preface, that there has long been a need for a "small, concise and practical treatise" on petrology in which the subject is dealt with entirely from a megascopic standpoint. Mining engineers and others who have to deal with rocks in a practical way have also felt the urgent need of such a book for purposes of reference. In our opinion the present manual meets this need in a highly satisfactory manner, and its publication marks a distinct advance in the treatment of elementary petrology. A general idea of the scope of the book may be obtained from the table of contents which follows:

Part I., Introductory and General Considerations. Chapter I., Scope of Petrology: Historical Methods of Study; Chapter II., Chemical Character of the Earth's Crust and its Component Minerals.

Part II., Rock Minerals. Chapter III., Important Properties of Minerals; Chapter IV., Description of the Rock-making Minerals; Chapter V., Determination of the Rock-making Minerals.

Part III., The Rocks. Chapter VI., General Petrology of Igneous Rocks; Chapter VII., Description of Igneous Rocks; Chapter VIII., Origin and Classification of Stratified Rocks; Chapter IX., Description of Stratified Rocks; Chapter X., Origin, General Characters and Classification of the Metamorphic Rocks; Chapter XI., Description of the Metamorphic Rocks; Chapter XII., The Determination of Rocks; Index.

The arrangement of the material in the various chapters is admirable throughout, while discussions, descriptions and statements in general are accurate, clear, concise, yet sufficiently complete, and are written in a style which is attractive and easy to read. Chapter IV., dealing with the general petrology of the igneous rocks, seems particularly worthy of notice, since it presents such material of a general character, both practical and theoretical, as is really essential for a clear understanding of igneous rocks, in a manner entirely in keeping with the most recent developments of the science, and yet within the comprehension of those not thoroughly trained in physical chemistry, nor in micro-petrology, a task that is not an easy one. An idea of the contents of this chapter may be gathered from the following topics, which are among those discussed therein: The modes of occurrence of igneous rocks; the chemical composition of magmas and their differentiation; the crystallization of silicate solutions (magmas) and the development of texture in igneous rocks; contact metamorphism; the classification of the igneous rocks.

In regard to the classification mentioned above, a system has been developed entirely consistent with megascopic petrology, all distinctions being based upon differences of texture or of mineral composition that can be made out by the careful study of good hand-specimens with the aid of a pocket lens, and a knife, in some few instances supplemented

by a simple chemical test. The first division is made on the basis of differences of grain (granularity) into three classes. These are divided according as the rock in question is porphyritic or non-porphyritic. Further division is made, chiefly upon differences of mineral composition, into a few broad groups which are designated by familiar rock names (granite, diorite, etc.) firmly fixed in petrological literature by long usage. The more important varieties falling under these various groups or kinds of rock, but which for microscopical or other reasons have received special names from petrographers, are referred to in appropriate places, so that the significance of such names when encountered can be easily found by reference to the book. Among the names adopted for the rock groups, it may be noted that *dolerite* has been retained, very wisely it seems, to designate those granular, igneous rocks, with predominant ferro-magnesian minerals but in which it is not possible to tell positively just what ferro-magnesian mineral is present. This group will therefore include much that is commonly referred to as diabase. *Felsite* (resp. felsite-porphyry) is used for those nearly or entirely dense rocks, light in color, and generally highly feldspathic in character, while basalt (resp. basalt-porphyry) covers those dense, dark-colored, igneous rocks, for the most part ferro-magnesian in character. It will be noted that both of these terms, felsite and basalt, have been given a broader meaning than is customary in books covering a somewhat similar field. For example, dacites and most andesites fall under the head of felsite. Directions, however, for recognizing such varieties when it is possible to do so macroscopically, are given. The classification is summarized in a convenient table on page 202.

While some teachers will doubtless wish to make some minor additions to the scheme of classification in their class-room work, the scheme as a whole appears so sane, simple and practical that it can not fail to meet with general approval, and it is to be hoped that it will also come shortly into general use. In such an event it would be a strong influence toward uniformity and simplicity of practise among field workers in geology and petrology.

In Chapter VII. we find the descriptions of individual kinds of rock treated under such appropriate headings as: Mineral Composition; General Properties; Chemical Composition (the latter illustrated by a few well-chosen analyses); Occurrence and Alteration. Thus while the descriptions furnish one with data useful for the recognition of the rock in the field or laboratory, they also furnish in a most satisfactory manner what might be termed the Natural History of the rock.

With so excellent a manual available as a basis for petrological study it is to be hoped that it may be substituted for the dry and generally uninteresting lecturing so common in petrological laboratories, as well as for the too numerous laboratory guides and notes of inferior quality, and thus promote a general improvement in petrological teaching.

In conclusion it may be said that the book is conspicuous by reason of its typographical excellence and for the superior quality of the illustrations which admirably illustrate the text.

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Die Pendulationstheorie. Von Dr. HEINRICH SIMROTH, Professor an der Universität Leipzig. Octavo, S. 564, Karten 27. Leipzig, Konrad Grethlein's Verlag, 1907. Pr. brosch, M. 12.

Theories of polar pendulation, based on geological or geographical considerations, have been proposed independently in the past few years by two investigators, one[1] an engineer, another[2] a geologist. To Professor Simroth alone among biologists, however, does the idea seem to have appealed as worthy of attention for its possible value in explaining the facts of zoogeography.

[1] Paul Reibisch, "Ein Gestaltungsprinzip der Erde," 27 *Jahresber. Ver. f. Erdk. zu Dresden*, 1901, S. 105–124. II., *ibid.*, 1905, S. 39–53, 2 Karten.

[2] D. Kreichgaur, "Die Aquatorfrage in der Geologie," Steyl, 1902.

The theory of Reibisch (rather than that of Kreichgaur), which the author has chosen as his working hypothesis, was first suggested to its originator as a tentative explanation of certain puzzling geographical facts. In particular is mentioned that the west coast line of South America becomes higher as one proceeds southward from the equator; and that recent coral reefs in the Pacific are partly in the condition of rising and partly in that of sinking. These differences are explained, according to Reibisch, if in addition to the difference between the rotational and equatorial diameters of the earth (40 km.), we assume a slow "pendulation" of the globe on an axis approximately perpendicular to the rotational axis, whose poles lie in the vicinity of Ecuador and Sumatra. In consequence of the greater equatorial diameter it follows that as a body of land in pendulation approaches the equator it will tend to be submerged, and that as it approaches the rotational poles it will correspondingly rise. This effect of the swing on land elevation will be greatest along the "Schwingungskreis," a great circle about the earth marking the greatest amplitude of swing. The Schwingungskreis passes through the two rotational poles, traverses the Pacific across its middle, crosses the Scandinavian Peninsula and the continent of Europe southward, and lops off the northwest quarter of Africa. In conformity with this theory the terrane quadrant embracing the North Atlantic, Europe, North Africa, and all of Asia except the east third is supposed now to be in "equatorial pendulation," that is, is nearing the equatorial position in the swing on the Sumatra-Ecuador pole. The same quadrant is assumed to have had a position farther northward in the glacial period, and to have lain farther southward in the Jurassic and Cretaceous. The "South Pacific" quadrant likewise is assumed to be now gradually approaching the equatorial position (in "equatorial phase"); while the "North Pacific" quadrant, embracing also the eastern third of Asia, and North America with the exception of Greenland and the Labrador region, is receding from the equator (in "polar phase"). The "Atlantic-India South" quadrant, taking in the bulk of the Indian Ocean, the south Atlantic, lower Africa, and South America below Ecuador, now finds itself approaching the polar phase. The region of the swing-poles themselves is necessarily subject to little swing, and is therefore supposed to have endured in the course of geologic ages little or no large climatic change.

In his general introductory discussion, following the exposition of the mechanics of the Reibisch hypothesis, and dealing in a broad way with the significance of pendulation in the origin and distribution of organisms, Professor Simroth enrolls himself with the adherents of the Kant-Laplace theory and takes no account at all of later theories of earth-origin. It is accordingly assumed that life must have arisen at a time of average higher temperature than prevails at present. On the question of the place of origin of the first organisms the Reibisch theory is regarded happily as broad and flexible enough to cover the requirements of any of the various suppositions that have been made. To the Laplacian and pendulationist it need make little difference whether it is held that life arose on land or in the water, at the rotational poles or in the tropics. The hypothesis of a gradually cooling globe, however, favors the supposition of the origin of life at the poles or on the mountains—these being the most cooled situations at any given time after surface solidification. And with further cooling must begin the pro-tropical migration, *for need of warmth*, that in time results in the concentration of a large primitive fauna in the tropics (liberally defined), to form the starting point of the succeeding movements which Professor Simroth finds the pendulation theory so helpful in explaining. If the "Urthiere" are already there, so much the better. If not, it is scarcely less easy than necessary to get them there, or at least started in that direction. For the companion assumption that the "great bulk of the most ancient known forms of life have lived, first or last, in the tropics, where they arose, or whither they had been driven by the advancing cold," is of cardinal importance in any endeavor to explain animal distribution in accordance with a principle of

pendulation. Of the truth of such an assumption it is held that the facts of paleontology, as well as our knowledge of the distribution and relationships of living forms, furnish an encouraging amount of corroborative evidence.

With the two hypotheses of pendulation and a concentration of a primitive fauna in the tropics established or granted, we are all but ready to follow the ensuing movements that are conceived to have determined the manner and direction of the dispersals of the past and of to-day. A circumequatorial movement, *away* from the vicinity of the swing poles themselves and toward the Schwingungskreis, is all that remains necessary in order to get these populations of old within the "sphere of influence" of the swing. This lateral movement is conceived as practically a logical necessity, those forms of life inhabiting the hot zone, and especially those portions of it with most equable temperature, *i. e.*, about the swing-poles, being *forced as they increased in numbers to begin an effort to extend their range in a like temperature and so long as no obstacles of the medium or other kind stood in the way.* How inevitable are the consequences of pendulation to a "caught" population, in the view of the author, once the preceding suppositions have been allowed, is evident from the following quotation: "An organism that has arisen under the Schwingungskreis [or has migrated there or near there] will as a consequence of pendulation be mechanically removed from its proper climate unless it moves out to the right and left on its own parallel. . . . Its distribution thus becomes discontinuous. It will inhabit two separated areas [transversally symmetrical points] which lie one to each side of the Schwingungskreis," the eastward or westward migration only coming to a stop when first a point is reached "which most nearly resembles climatically the original habitat." Among the more salient examples of transversally symmetrical points offered by the author are: the alligator, the sole Asiatic species of which lives in the Yang Tse Kiang, while the nearest related form found elsewhere inhabits the lower Mississippi; the shovel-nosed sturgeons, of Turkestan and the Mississippi Valley; *Psephurus* and *Polyodon;* the dipnoans, *Lepidosiren* and *Ceratodus;* species of *Cryptobranchus, Limulus, Pleurotomaria;* points of maximal abundance of landsnails, etc. The map (No. 5) exhibiting the geographical relations of the most striking of these cases of "transversal symmetry" adds much clearness and force to this portion of the text. The predictableness of location of these transversally symmetrical points in the light of a "Pendulations-mechanik" leads the author to observe of the first expedition sent out to search for dipnoans in South America, that the unsuccessful search in the Amazon region was the result of a "false scent" wholly unnecessary had the biologists of those days possessed our present knowledge. Without pendulation "what a keen hypothesis were necessary," he asks, in order to furnish so clear and certain an elucidation of these instances! That all species or faunas caught by the swing should thus move out laterally from the Schwingungskreis and their little (or much) modified descendants so come to occupy such symmetrically situated habitats is too much to be expected and is not a meaning intentionally conveyed by the author. The length of time required for a full pendulation, for example, the interval between the Jurassic and the Tertiary, would seem, for one thing, to leave ample time for such of the forms affected as might choose to remain stationary to adapt themselves to the changed conditions. And, again, as we shall see, the ways in which pendulation may work in influencing the changes and movements of organisms are more than one.

That mode of distribution called by the author "meridial symmetry" is another interesting phenomenon on which light is thrown by the pendulation theory. Thanks to it, the occurrence of closely related forms, for example, in California and Chili and in Japan and Australia need no longer puzzle. "Forms once carried northward with the polar swing, in the next equatorial phase are carried into too warm a temperature, and either move out eastward or westward or ascend mountains. On the latter they can go further south and

even cross the equator. On the other side of the equator they may come down gradually from the mountains. . . . Close investigation always discloses the fact that the original starting point of these migrations was on the Schwingungskreis."

Still another useful function of the Reibisch theory is the explanation of the common arc-shaped (Bogenförmig) life-area. This type of distribution is assumed to be due to the effect of the organism's meeting the "Kulminationskreis" in its eastward or westward migration. It should be explained that the Kulminationskreis is a great circle which passes through Ecuador and Sumatra at right angles to the equator, and is so named because it marks the position of nearest approach to the rotational poles that can be attained by any point on the globe's surface during pendulation. In an eastward or westward movement of a species, when the Kulminationskreis is reached, a halt and change of direction is likely to be made, since at this point opposite conditions of climate set in. For example, an organism passing northwestward through that portion of North America lying in the Atlantic-Indic North Quadrant (which is in equatorial phase) enters, when it crosses longitude 80° west, a quadrant which is in its polar phase. The turn southward follows and the "Bogenförmig Areal" is the result.

Especially interesting is Professor Simroth's very brief discussion of the character of the fauna of the swing-pole regions themselves. Here, where pendulation has been so little as to be practically negligible as an agent of climatic change, we might expect to find the homes of many very ancient forms of life, such as have never experienced the necessity of moving. That a comparison of the faunas of both east and west swing-pole regions with that of extra-polar areas reveals a gratifying number of primitive forms is held to be true by the author. And the existence is asserted of a mass of botanical writings whose purpose has been to establish how little the recent flora of both swing-pole regions differs from that of the Tertiary.

The preceding brief review of the effects on the movements and evolutionary changes in species and faunas that might be expected through the operation of pendulation has been without reference to the effects of the land upheavals and submergences that are a necessary consequence of the pendulation principle. Of these latter and their effects, so largely speculative, little is offered by the author or could be expected. As further examples of equatorial sinkings are mentioned the Caspian area, the Dead Sea, North Africa and North Australia. Such broad low flat areas as the Sahara, in particular, because of their lack of defensive or refuge-furnishing barriers, are believed to have been of high importance as factors in the initiation of evolutionary changes. Animals and plants originating in such a place must make more than ordinary effort to keep in an equable climate. For such pendulation has the mandate: move or vary. In considering the eventuality that some might stay, it is ventured that "only the strongest mutations would suffice" those that did. To those that move several alternatives are open. They may go east or west on their own meridian. If there are mountains, they may ascend them. In a polar movement they may attain greater warmth, perhaps, by voluntarily descending into the sea; while in an equatorial movement which involves a stretch of continent already low, many will be forced into the sea with the gradual submergence.

Estimates of the value of as purely speculative a piece of work as this are so apt to vary with individual temperament or scientific interest that they are little better than gratuitous. When the issue between the author and his public (for the book is confessedly a brief) is so largely one of interpretation, the pointing of minor errors of fact, unavoidable in so great a massing of material from so wide a field, has scant relevance. Beside the conception in defense of which the author's thesis has been written, even a vaster compilation of biological data than Professor Simroth has brought together might well have for many an appearance of comparative insignificance. So it will doubtless be easier for most readers to admit a considerable measure of explaining value in

the theory, once granted, than to grant it and its retinue of corollary assumptions. But the mere novelty and unfamiliarity of the conception, not to say the strange difficulty that the reader experiences at first in orienting himself in a pendulating world, need hardly of itself invite to indifference or contempt. A hypothesis, however unproven or unprovable, which puts into such new and clear light so many obscure phenomena seems to me to deserve, at least at the hands of students of distribution, a modicum more of attention than has recently been accorded it by a British reviewer. As for the ultimate disposition of such theories as those of Reibisch and Kreichgaur, that is clearly more likely to fall within the province of astrophysics than of faunistic biology.

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MOREHOUSE'S COMET

A COMET was discovered photographically at the Yerkes Observatory on the evening of September 1, by Professor D. W. Morehouse, of Drake University, Des Moines, Ia., who has been engaged in graduate work during the summer under the direction of Professor Barnard.

The comet's position on the three plates simultaneously exposed on that night was approximately: R. A. $3^h\ 20^m$; Dec. North $+66°$.

Several photographs were also obtained by Professors Barnard and Morehouse on September 2 and 3, from which quite accurate positions will be determined. The tail is shown on the plates for a length of about six degrees, and exhibits some interesting structure. Although the comet made a strong impression on the discovery plates, it was faint visually when seen on the following night, and was without any definite nucleus. The coma was not large, but was uniformly diffuse.

A micrometric position was obtained with the 12-inch refractor by Mr. Fox, as follows: Sept. 2, G. M. T., $17^h\ 45^m$, R. A. $= 3^h\ 21^m\ 55^s$; Dec. $= +66°\ 52'\ 24''$.

The motion is thus seen to be toward the north, with a slight westerly component. The comet is of course above the horizon in northern latitudes through the whole night.

EDWIN B. FROST
YERKES OBSERVATORY,
September 4, 1908

SPECIAL ARTICLES

NOTE UPON THE STRUCTURE OF THE SANTA CATALINA GNEISS, ARIZONA

THE extensively-developed pre-Cambrian gneiss of the South side of the Santa Catalina Mountains near Tucson, Arizona, is remarkable for its tabular form; its regular stratification; its altitude at low angles; its broad flat surfaces and in places, for its extreme foliation, passing from coarse grained tabular granitic-gneiss into micaceous, sericitic and hornblende schists. Seen from a distance, especially from the locality known as Gibbon's Ranche, the croppings appear like ordinary stratified sandstones and shales. Close inspection reveals an elongated drawn out and flattened structure, which it is the special object of this paper to note.

The whole series appears to have been elongated under great pressure, resulting in flattening and spreading out into thin layers with a consequent reduction of thickness and an increased lamination.

I purposely refrain from describing this modification of form as a "flow" or as "flow-structure" for these terms convey the impression of a much more mobile condition than existed and of superficial movement rather than of the interior elongation by stretching under great pressure of a deeply seated mass of comparatively solid rock.

The compression and extension are shown in several ways, but specially by the elongation of nodules of feldspar; by sheets of quartz which seem to have been rolled out like dough and impressed by nodular masses of feldspar above and below.

The phenomena remind the observer of the curiously elongated rocks in California; the "grave-stone slates" and sandstones of the middle gold region, which are there uplifted at high angles, while in the Catalina gneiss the dip is gentle, approaching horizontality.

even cross the equator. On the other side of the equator they may come down gradually from the mountains. . . . Close investigation always discloses the fact that the original starting point of these migrations was on the Schwingungskreis."

Still another useful function of the Reibisch theory is the explanation of the common arc-shaped (Bogenförmig) life-area. This type of distribution is assumed to be due to the effect of the organism's meeting the "Kulminationskreis" in its eastward or westward migration. It should be explained that the Kulminationskreis is a great circle which passes through Ecuador and Sumatra at right angles to the equator, and is so named because it marks the position of nearest approach to the rotational poles that can be attained by any point on the globe's surface during pendulation. In an eastward or westward movement of a species, when the Kulminationskreis is reached, a halt and change of direction is likely to be made, since at this point opposite conditions of climate set in. For example, an organism passing northwestward through that portion of North America lying in the Atlantic-Indic North Quadrant (which is in equatorial phase) enters, when it crosses longitude 80° west, a quadrant which is in its polar phase. The turn southward follows and the "Bogenförmig Areal" is the result.

Especially interesting is Professor Simroth's very brief discussion of the character of the fauna of the swing-pole regions themselves. Here, where pendulation has been so little as to be practically negligible as an agent of climatic change, we might expect to find the homes of many very ancient forms of life, such as have never experienced the necessity of moving. That a comparison of the faunas of both east and west swing-pole regions with that of extra-polar areas reveals a gratifying number of primitive forms is held to be true by the author. And the existence is asserted of a mass of botanical writings whose purpose has been to establish how little the recent flora of both swing-pole regions differs from that of the Tertiary.

The preceding brief review of the effects on the movements and evolutionary changes in species and faunas that might be expected through the operation of pendulation has been without reference to the effects of the land upheavals and submergences that are a necessary consequence of the pendulation principle. Of these latter and their effects, so largely speculative, little is offered by the author or could be expected. As further examples of equatorial sinkings are mentioned the Caspian area, the Dead Sea, North Africa and North Australia. Such broad low flat areas as the Sahara, in particular, because of their lack of defensive or refuge-furnishing barriers, are believed to have been of high importance as factors in the initiation of evolutionary changes. Animals and plants originating in such a place must make more than ordinary effort to keep in an equable climate. For such pendulation has the mandate: move or vary. In considering the eventuality that some might stay, it is ventured that "only the strongest mutations would suffice" those that did. To those that move several alternatives are open. They may go east or west on their own meridian. If there are mountains, they may ascend them. In a polar movement they may attain greater warmth, perhaps, by voluntarily descending into the sea; while in an equatorial movement which involves a stretch of continent already low, many will be forced into the sea with the gradual submergence.

Estimates of the value of as purely speculative a piece of work as this are so apt to vary with individual temperament or scientific interest that they are little better than gratuitous. When the issue between the author and his public (for the book is confessedly a brief) is so largely one of interpretation, the pointing of minor errors of fact, unavoidable in so great a massing of material from so wide a field, has scant relevance. Beside the conception in defense of which the author's thesis has been written, even a vaster compilation of biological data than Professor Simroth has brought together might well have for many an appearance of comparative insignificance. So it will doubtless be easier for most readers to admit a considerable measure of explaining value in

the theory, once granted, than to grant it and its retinue of corollary assumptions. But the mere novelty and unfamiliarity of the conception, not to say the strange difficulty that the reader experiences at first in orienting himself in a pendulating world, need hardly of itself invite to indifference or contempt. A hypothesis, however unproven or unprovable, which puts into such new and clear light so many obscure phenomena seems to me to deserve, at least at the hands of students of distribution, a modicum more of attention than has recently been accorded it by a British reviewer. As for the ultimate disposition of such theories as those of Reibisch and Kreichgaur, that is clearly more likely to fall within the province of astrophysics than of faunistic biology.

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MOREHOUSE'S COMET

A COMET was discovered photographically at the Yerkes Observatory on the evening of September 1, by Professor D. W. Morehouse, of Drake University, Des Moines, Ia., who has been engaged in graduate work during the summer under the direction of Professor Barnard.

The comet's position on the three plates simultaneously exposed on that night was approximately: R. A. $3^h\ 20^m$; Dec. North $+66°$.

Several photographs were also obtained by Professors Barnard and Morehouse on September 2 and 3, from which quite accurate positions will be determined. The tail is shown on the plates for a length of about six degrees, and exhibits some interesting structure. Although the comet made a strong impression on the discovery plates, it was faint visually when seen on the following night, and was without any definite nucleus. The coma was not large, but was uniformly diffuse.

A micrometric position was obtained with the 12-inch refractor by Mr. Fox, as follows: Sept. 2, G. M. T., $17^h\ 45^m$, R. A. $= 3^h\ 21^m\ 55^s$; Dec. $= +66°\ 52'\ 24''$.

The motion is thus seen to be toward the north, with a slight westerly component. The comet is of course above the horizon in northern latitudes through the whole night.

EDWIN B. FROST
YERKES OBSERVATORY,
September 4, 1908

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The phenomena remind the observer of the curiously elongated rocks in California; the "grave-stone slates" and sandstones of the middle gold region, which are there uplifted at high angles, while in the Catalina gneiss the dip is gentle, approaching horizontality.

The sections of the Catalina rocks show a great variety of mineral composition ranging from quartzite to muscovite-schist and biotite-schist. There can be little doubt of their elastic origin, though they are now penetrated by layers of pegmatitic granite, which partake of the deformation.

These gneissic and schistose rocks are members of the series of pre-Cambrian schists for which I proposed the name "Arizonian." They are widely distributed in middle and southern Arizona and offer an inviting field for investigation.

Wm. P. Blake

Tucson, Arizona

Physiographic Sketch of Lewis County, N. Y.

The county of Lewis, bounded on the northeast by St. Lawrence, on the west by Herkimer, on the south by Oneida and on the east by Oswego and Jefferson counties, extends from the 43° 25′ of northern latitude for fifty-four miles northward and from the 75° 50′ western longitude for nearly thirty-four miles to the east, and is naturally divided by Black River into two heterogeneous sections from a genetic point of view, an eastern section, made up to the greatest extent of igneous and metamorphic rocks, and a western one that chiefly comprises a sedimentary series.

Successive manifestations of dynamical forces upon the igneous rocks in the east, as the crushing of the granites into gneisses and the intrusions of syenites, as well as gabbros, into the gneissic series and into the crystalline limestone series, have affected also to some extent the sedimentary rocks in the west in such a manner as to slightly bend during post-Ordovician time Cambrian, Ordovician and (Lower) Silurian strata into a flat synclinal fold that plunges at a very small angle to the north-northeast, while subsequent erosion nearly completed one of its cycles by reducing post-Ordovician topography to a peneplain, remnants of which can still be traced in the most elevated portions of the western section.

During another cycle of erosion that was never completed, but only brought about the partial destruction of the peneplain and exposed in succession the different members of the Ordovician, *i. e.*, the Black River and Trenton limestone, as well as the Utica-Frankfort slates and the Pulaski sandstone shales, at least one member of the Silurian, namely the Oswego sandstone, and, bordering the Ordovician in the east, the Potsdam sandstone of the Cambrian, a strike fault west of Black River, extending through the entire length of the county and possibly beyond, caused the disappearance of the Potsdam sandstone along the fault line, thus bringing the pre-Cambrian igneous and metamorphic series into contact with the Ordovician.

Succeeding the faulting of the region and the invasion of ice sheets of local character from the Adirondack, as well as from the Lake Ontario region, which led to the formation of two distinct sets of ground and terminal moraines, a second flood plain was established, adjacent to the former, but on a much lower level, which we might consider a base-leveled plain, as its uniformity of level is admirable for its entire extension from the utmost northwestern points of the county for over forty miles, as far as Forestport, beyond the southern boundary line of Lewis County.

Into this flood plain post-glacial erosion has sunk in several successions, of which two are more prominently marked by river-terraces, the channel that is now occupied by Black River, and has modified the topography of the regions east and west of Black River to such an extent as to impart to them the physiognomy of uplands and highlands, respectively.

At present the area under discussion is passing through a cycle of erosion that has started recently, speaking geologically, and conditions have been established that apparently favor the rejuvenation of the entire drainage system of the region and the carving into the sedimentary strata in the west along joint planes and into the igneous and metamorphic rocks in the east without special regard to basal structure, of those deep gulfs

and precipitous gorges that contribute so much to the charms and scenic effects of a region.[1]

T. A. BENDRAT, M.S.
CONSTABLEVILLE, N. Y.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE HANOVER MEETING, SECTION E, JULY 1–3, 1908

AT the Hanover meeting of the American Association for the Advancement of Science, Section E, Geography and Geology, held two sessions for the reading of papers and participated in the excursions to Mt. Ascutney and Corbin Park. Prior to the gathering at Hanover, a party of geologists, which varied in number from eight to ten, enjoyed a trip from Bellows Falls, Vt., to Rutland under the guidance of Professor J. E. Wolff, to the marble quarries at West Rutland with Mr. G. H. Perkins, state geologist, and from Rutland to Woodstock in company with Professor Wolff and Professor C. H. Hitchcock.

The scientific sessions began Tuesday, June 30, at ten o'clock and, with an intermission for dinner, continued till 4:30 P.M. Mr. Bailey Willis, vice-president, called the meeting to order. In the absence of the sectional secretary, Dr. F. P. Gulliver, who was unfortunately too ill to attend, Professor J. E. Wolff consented to serve as secretary. After the opening of the afternoon session, Professor C. H. Hitchcock took the chair at the request of Mr. Willis and presided to the close of the session. The following papers were presented and discussed:

Local Geology of Hanover, N. H.: C. H. HITCHCOCK.

Professor Hitchcock after referring to his early work as state geologist and its continuation during forty years, described a large relief map of New Hampshire which he had prepared and from time to time brought up to date as geological investigations progressed. It is now colored to represent the state of knowledge in 1908. The accumulated collections and their arrangement in the Butterfield Museum of Dartmouth College were described, and attention was called to the device of connecting each specimen by an identical number with its locality shown in one of the eighteen sections, which had been prepared on a large scale to illustrate the relations of the rocks. Professor Hitchcock then stated in some detail the known and probable relations of the various igneous and metamorphic rocks of the Hanover quadrangle and showed a preliminary draft of a geologic map of that area. The strata being, so far as known, unfossiliferous, their age is inferred from comparison with related fossiliferous sections, which indicate that Cambrian, Ordovician and Silurian rocks may be present in the geosyncline that lies east of the Pre-Cambrian axis of the Green Mountains and extends into the western half of the Hanover quadrangle. The eastern half is a complex of intrusive and metamorphic rocks, on the western margin of a large area related to the zone of intrusions which traverses the middle of New Hampshire and culminates in the White Mountains. Passing on to the subject of glacial geology, the speaker described two sets of striæ, the one ranging south 10° west down the Connecticut Valley, the other southeast. Evidence that local glaciers occupied the valleys tributary to the Connecticut after the disappearance of the general ice sheet was briefly presented, and incidentally a map of Connecticut on a scale of 400 feet to the inch, prepared by the students of Dartmouth, was exhibited.

In discussion Mr. Willis stated that wide areas of schists and gneiss of New England, which were formerly considered to be Archean, are now generally classed as Paleozoic sediments and intrusives. These do not include the axis of the Green Mountains, which Professors Hitchcock and Wolff had described as Archean, but they cover all the province east of that range in Vermont, New Hampshire and Maine.

Recent Explorations in Mammoth Cave, with a Revised Map of the Cave: HORACE C. HOVEY.

Mr. Hovey stated that, of late, explorations in the unfrequented parts of Mammoth Cave have been pushed by several visitors, especially Messrs. Parrish and Einbigler, aided by the local guides. The results were laid before the author of this paper, who verified them by a personal visit in 1907; finding the newly discovered domes more grand than any previously known. These additions, and a number of minor corrections, had led him to prepare a new guide map, with an index and table of approximate distances, which he had now published and exhibited in connection with this paper. Dr. Hovey courteously presented copies of the new map of Mammoth Cave to those present at the meeting of the section.

The Warm Stratum existing at a Great Height in the Atmosphere: A. LAWRENCE ROTCH.

In 1901 it was discovered in Europe, by the use

[1] This article is a chapter of a report to be published on the geology of Lewis County, based on three seasons of field work.

of "ballons-sondes," that there was a warm, or isothermal, stratum in the atmosphere at a height of about 10 kilometers. In 1904 the author made the first use of "ballons-sondes" in the United States and in this and the following years sent up 77 balloons from St. Louis. Nearly all of the 71 recovered which rose higher than 12 kilometers entered the warm stratum. The largest inversion of temperature found was during the first ascension on September 15, 1904, when the minimum temperature of —52° C. occurred at a height of 14,600 meters, the temperature rising to —36° C. at 17,000 meters, the maximum height attained. Again, on October 8, 1907, the temperature fell to —67° C. at 14,500 meters and rose to —58° C. at 16,500 meters, the stratum of inversion descending 2,500 meters within the next two days. In summer its level is somewhat lower than at other seasons. It seems probable that this warm stratum extends completely around the globe. It lies lower in northern Europe, but it was not discovered at the equator by the balloons that rose 15 kilometers from a yacht sent to the South Atlantic in 1906 by M. T. de Bort and the author.

Discussed by Professor T. C. Chamberlin.

High-level Terraces of New England: J. W. Spencer.

The author presented and described longitudinal sections of the river valleys radiating from the White Mountains. They show a succession of terrace steps descending the valleys, the surfaces of which slope very gently down the valleys, each one passing by abrupt transition to the next below. Each begins in a river flat, becoming a terrace further down the stream, where remains of several terraces, one above the other, may be seen. In one case, as in the Lemaile Valley, the slope was found to be forty-five feet in fifteen miles. These phenomena are found from the high mountain passes, such as Profile and Crawford notches, to within a few hundred feet above sea level. They suggest that in them be found data bearing on the Post-glacial elevation of the mountain masses.

Discussed by Professor J. W. Goldthwaite.

Note upon the Structure of the Pre-Cambrian Gneiss of the Santa Catalina Mountains, Arizona: Wm. P. Blake.

The Pre-Cambrian gneiss of the Santa Catalina Mountains is remarkable for its tabular stratification at a low angle of dip; its permeation by pegmatite with the formation of feldspar nodules, and its extreme foliation in some parts, passing from coarse-grained gneiss to schists in various forms, micaceous and hornblendic.

But the chief characteristic to be here noted is its evident elongation under great pressure.

Studies of the Tracks of Climatichnites: C. H. Hitchcock and W. Patten.

A large slab of sandstone crossed by several trails was exhibited where installed on the walls of Butterfield Museum. Professor Patten described the movements of a modern *Limulus* in advancing up a sandy beach with the tide and the action of the abdominal gill plates making rhythmic ridges in the sand. He compared these with the tracks of Climatichnites, which he ascribed to forms related to the Eurypterids rather than the trilobites. The tracks showed a beginning in a hollow in the sand and where continued on the specimen to the further end there became fainter, as if the animal rose from the bottom. This would correspond with the habit of the *Limulus,* which remains buried on recession of the tide and upon its return first crawls and then swims away. Beside one track were seen two symmetrically placed impressions attributed to the longer arms of a Eurypteroid form.

The Attitude of the Algonquin Beach; and its Significance: J. W. Goldthwaite. (Illustrated by lantern slides.)

Precise measurements of altitude of the Algonquin beach and other "raised beaches" bordering Lake Michigan indicate that in that basin the Algonquin beach slants southward at a repeatedly diminishing rate, becoming horizontal near Manistee, Mich., and Kewaunee, Wis. South of a line through these localities the Algonquin beach is invariably 593–598 feet A. T. This horizontality over the southern half of the Lake Michigan basin appears to mean that the beach there is now at the altitude at which it stood when first formed, and that it has been undisturbed by those differential uplifts which have warped the more northerly parts of the Great Lake district. In other words, Lake Algonquin appears to have stood approximately 600 feet A. T. when the "Algonquin Beach" was built.

Mr. F. B. Taylor found what is probably the same beach at an altitude of 1,220 feet A. T. near South River, 30 miles south of the pass between Lake Nipissing and the Mattawa River. It is quite possible that the plane of this Algonquin beach, extended over the Nipissing Pass, would be at least 1,300 feet A. T. there. If so, that dis-

trict has risen approximately 700 feet since the beach was formed.

If we restore the district near the Nipissing pass to the position which it had at the Algonquin stage, by lowering it 700 feet below its present position, we put the floor of the Nipissing pass (which is now less than 700 feet A. T.) a little below sea level. This suggests the possibility that the sea may have entered the basins of the Great Lakes from this direction.

The conjectured altitude of Lake Algonquin, 600 feet A. T., is attributed to an ice barrier over the Nipissing pass. It is very probable that this barrier persisted until the floor of the pass had been raised well above sea level, by the differential uplifts which produced the diverging series of beaches below the Algonquin. If the sea did come in through the Nipissing Pass, however, a record of it might be expected in raised beaches north of the pass.

Professor Goldthwaite was followed by Dr. J. W. Spencer, who presented the two following papers, both of which were illustrated by lantern slides.

Changes in the Recession of the Falls of Niagara.

The following is a mere summary of some of many chapters required in describing phenomena which bring to light the changing features of Niagara Falls.

From my own measurements of the recession of Niagara Falls, compared with those of Hall in 1842, I find that the average rate is 4.2 feet a year for the width of the canyon (1,200 feet) made by the cataract; and from the discovery of its position in 1678, approximately the same rate formerly prevailed.

From a point 1,100 feet below the apex of the falls, to the Whirlpool, I find by my new soundings, that the depth of the gorge reaches to the same plane of 86 to 92 feet below the level of Lake Ontario, when allowance is made for the descent of the river surface at the Whirlpool Rapids, where borings show that the canyon was trenched to the same depth as above and below them by the falls. But soundings, which I succeeded in making immediately below the falls themselves, prove that the cataract can excavate to a depth of not over 100 feet below the river surface, consequently the present deep channel of 186 to 192 feet could have been made only when the falls were higher—that was before the gorge at the Whirlpool Rapids had become partly refilled by the recent falling of the adjacent wall-rocks. At this section, for a short time, the volume of the river was diminished by the temporary partial diversion of the Upper Lake drainage, by way of Chicago. Until the falls had crossed the Lyell ridge, about a mile and a half below their present site, they were somewhat higher than now. By the trenching of this ridge the surface of the river was lowered by about sixty feet, on account of the removal of the drift from the pre-glacial valley, which they took possession of, whereupon the Upper Rapids came into existence. The site of the Whirlpool was the head of a pre-glacial canyon, above which was a small tributary heading in the Lyell ridge, two miles away, since deepened by the falls. Below the whirlpool to the head of Foster's Flats (about two thirds of a mile), the gorge is similar to that above, and here there was a slight change in the height of the falls, as explained. Throughout these four miles the greater height of the falls increased the rate of recession. By differentiating the work of the falls at each point, the time required for the formation of this longitudinal stretch of the gorge is now computed to have been 3,500 years only.

The history of the lower three miles is entirely different. At their birth, the falls were only 35 feet high—shown by a terrace at the mouth of the gorge. From time to time the falls increased in height as the Ontario waters retreated to lower levels, even to 180 feet below the level of the present day—shown by the deep inner channel revealed by my recent soundings. The falls then reached over 500 feet in height, but consisted of three separate cataracts, the lowest of which was over 300 feet high; however, its work as rapids was exhausted in excavating a new channel for over eleven miles beyond the end of the gorge, while the upper cataracts were already far advanced within the canyon. Shortly after the third cataract, now a fall, had receded half a mile within the gorge, its height was reduced by nearly 180 feet, owing to the rising of the Ontario waters, due to the warping of the earth's crust at the outlet of the lake.

The second cataract gained upon the upper one, until the two united at a well-marked point at Foster's Flats, less than three miles from the mouth of the gorge. At this time they had each reached about 120 feet in height. A few hundred feet beyond this point, at the head of the flats, occurred the most remarkable change in the history of the river. Until this time the volume of the river was only that of the Erie drainage, the three upper lakes emptying to the northeast, as

I discovered in 1888. The volume of the Erie drainage is now found to have been only 15 per cent. of the present discharge of Niagara River. The change mentioned consisted of a new force breaking through the hard sandstone floor of the river to a great depth, as found by the new soundings, and making a much greater channel than the united falls had been able to produce. This increased force arose from the addition of the full discharge of all the upper lakes, which is now thus established to have taken place, when the falls were at this point.

Throughout this lower section of about three miles, the work performed by the upper cataract has been determined. Therefore, by applying the laws of erosion, it became possible to calculate the approximate age of this section of the gorge. Had it been necessary to depend upon the work of the second and third cataracts, it is hardly likely that any reliable determination could have been made. The results show that a period of 35,500 years was required for the recession of the falls in this lower section or 39,000 years in the whole length of the canyon.

The turning of the Huron drainage into Lake Erie occurred 3,500 years ago, and it is 3,000 years since the falls reached the whirlpool. They were passing the site of the Whirlpool Rapids from 2,500 to 2,000 years ago, while the rapids themselves were completed less than 300 years since.

Pre-glacial Erie Outlet.

The Erie Basin formed a depression in the Devonian shales, bounded on the north by a narrow ridge, capped by Corniferous limestone. This was faced on its northern side by a low escarpment, descending to the basin in the soft rocks of the Salina formation, which was bounded on its northern side by durable Niagara limestone. The escarpment and basin mentioned are now leveled over by drift formations. Beyond the Niagara limestone there was again a parallel trough of the Ontario basin, excavated out of soft Medina shales. Such was the pre-glacial character of the Niagara peninsula between Lake Erie and Lake Ontario.

Many years ago I found that the ridge of Niagara limestone, at the head of Lake Ontario, was trenched sufficiently deep to at least draw water from the Erie basin. Another trench to a depth of 28 feet below the surface of that lake occurs along the Welland Canal.

Upon investigating the character of the rock-bound basin at Niagara Falls, I found that it did not lead to the north, as was supposed, but rapidly widened and deepened to the southwestward, even to one hundred feet below the surface of Lake Erie. Determined to find whither this pre-glacial valley led, I collected the records of borings, and made other borings, with the result that a deep pre-glacial valley was discovered cutting the Corniferous limestone for a breadth of less than two miles, immediately east of Lowbank Post Office, and crossing the Salina basin, and again trenching the ridge of Niagara limestone (here forming a canyon) filled with drift, but partly reopened by the modern streams, just west of De Cou Falls, the inner canyon being somewhat more than a mile, and the outer more than two miles in width. With allowance for the measured post-glacial uplift, this buried valley, revealed by borings at almost every mile, was sufficiently deep to drain the pre-glacial Erie valley, receiving, as it did, the ancient Ohio and Alleghany rivers as tributaries. These gorges through the hard ridges between the buried valleys resemble the courses of streams crossing the Appalachian ridges. The discovery of this ancient water course is one of the most completely demonstrated of all those bringing to light the great changes of drainage since pre-glacial days, and is a lesson for further research.

This closed the sectional meeting.

The excursion to Mount Ascutney, Wednesday, July 1, was shared by twenty-two members. A number accompanied Dr. Daly in a drive about the base of the mountain and to Little Ascutney to examine the igneous rocks and contact phenomena. The others ascended the principal height. In the view from the summit the oldest recognizable peneplain of the region was studied and certain differences of opinion as to its character were developed. To some of those present, the reduction of the surface toward a general peneplain appeared less complete than had been expected, and the appearance of the topography suggested that of certain mid-Tertiary slopes and heights.

From the excursion to Mount Ascutney members of Section E returned to Hanover to take part in the general exercises, including the trip to the Corbin Game Park on Thursday, July 2.

On Friday and Saturday a number proceeded from Hanover to Littleton, N. H., under the guidance of Professor Hitchcock, and examined the stratigraphy of the Silurian rocks, from which trilobites and brachiopods were collected.

Bailey Willis